Whittell Forest Fuel Reduction and Ecosystem Enhancement Plan

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Plan Summary

The Whittell Board proposes to initiate a series of treatments aimed at reducing the potential for high intensity wildfire and improving ecosystem health in portions of the Whittell Forest (Little Valley). After 45 years of following the mandate of the University of Nevada's Board of Regents to maintain the forest in a primitive state, the Whittell Board recognizes that the effects of drought, insect infestations and fire suppression policies have created unsustainable and hazardous conditions in Little Valley, as in many forests in the western U.S. We propose to thin crowded stands of trees by removing saplings and small trees, to reduce ladder fuels, and to eliminate slash, ground and surface fuels from the forest using prescribed fire. The Whittell Forest has been and will continue to be managed as a primitive area. All treatments will be conducted with hand tools by personnel on foot. Some fuels will be removed in the form of firewood or logs used to construct a fence. The Nevada Division of Forestry (NDF) or other qualified entities expressly approved by NDF/UNR will conduct all prescribed burns. We have assessed several alternative means of treatment, including ground-based commercial logging, chipping and hauling fuels, grazing, and taking no action, but conclude that none of these methods can effectively reduce fuels and restore ecosystem health while maintaining the Whittell Forest as a primitive area. The economics and feasibility of helicopter logging will be investigated. The treatments we propose will permit the careful and gradual reintroduction of fire as a key disturbance process in the forest, which will help restore ecosystem health. Fuel reduction will decrease the risk of wildfire not only in the Whittell Forest but also in surrounding areas. The goal is to return forest structure and forest processes to within the range of natural variation (i.e., similar to the structure and functioning of presettlement forests). We aim for this goal not only because it represents historic conditions but because it represents sustainable conditions.

Analysis of fire scars on trees and stumps has revealed that before European settlement of the eastern Sierra Nevada, fires burned in mid-elevation Jeffrey pine forests similar to those in Little Valley at intervals of ≈5-15 years. Such frequent fires consumed most plant litter and coarse woody debris. Consequently, the presettlement fires were usually starved for fuel, burned relatively cool across the ground or through the forest understory, and were often small or patchy. This fire regime resulted in an open forest structure with relatively few, large, widely-spaced trees with few branches within 5 m of the ground, little dead woody debris, a sparse understory of shrubs, and a forest floor consisting mostly of mineral soil.

The situation changed following settlement of the area by Europeans in the 1850s and near clear-cutting of the forests of the Carson Range in the 1860s and 70s to provide lumber and fuel for the Comstock mining boom in Virginia City. By the early 1900s, federal, state and local governments had instituted a policy of fire suppression throughout the western United States. In the absence of fire, fuels have gradually accumulated during the twentieth century, rising to unprecedented levels by the 1960s. Extensive crowding of forests in recent decades, coupled with several prolonged droughts, has created opportunities for bark beetles to attack trees stressed by lack of water. The thousands of trees they have killed now add to already heavy fuel loads. Today forests of the Carson Range are markedly different from those of presettlement times, with numerous small trees crowded into dense stands, numerous standing dead trees, and many logs on forest floors that are covered with thick deposits of needle litter, cones, twigs, and branches. In forest openings, shrubs are dense and the lower branches of trees often extend to the ground surface. These conditions represent a serious risk that a lightning- or human-caused ground fire could spread quickly into the canopy of live trees and burn intensely through entire stands.

According to the plan presented in this document, treatment over the next 5-10 years will occur on ≈360 acres of Little Valley in a strip 300-400 m wide extending from the south property line to the north property line. This area in the valley bottom was chosen for three reasons. First, this is the safest area in which to begin treatments because most of the treated areas will be within 150 m of existing roads, providing access to firefighting crews and equipment during prescribed fires. Second, the Jeffrey pine forest and meadow habitats where most of the treatments will be conducted are those habitats that have been most affected by more than a century of fire suppression. These habitats have missed about 13 fire cycles. Third, this area forms a strategic zone, which, once treated, will create a defensive network that can be used to combat a regional fire. The area proposed for treatment in Little Valley is contiguous with areas that have been thinned in the late 1980s or are targeted for treatment by the US Forest Service as part of the North Washoe Valley Wildfire Risk Reduction and Ecosystem Enhancement Project. Together these areas will form a zone >9 km long with greatly reduced fuel levels. In the event of a future wildfire, this strategic zone will slow the spread of fire, cause fire to drop from the tree canopy to the ground, and provide a safe area in which firefighting crews could work to combat a regional fire.

The proposed treatment areas in the Whittell Forest consist of ≈200 acres of Jeffrey pine forest, ≈75 acres of mature lodgepole pine forest, and ≈85 acres of dry meadow that have been invaded by young lodgepole pine since 1965. Forty-six treatment units have been defined (averaging ≈8 acres each), 22 in Jeffrey pine forest, 8 in lodgepole pine forest, and 16 in the dry meadow. The proposed activities on each treatment unit will vary depending on habitat and fuel conditions, but most treatments will include thinning of young white firs, lodgepole pines and Jeffrey pines, cutting of standing dead trees, removing ladder fuels, and preparing the site (e.g., establish fire lanes, lay fire hoses, etc.) according to an approved fire prescription, followed by pile burning of woody debris and broadcast burning.

Prescribed fire will only occur under prescription, only during the non-fire season (late autumn or early spring), and only under favorable weather conditions. Prescriptions will be written by Nevada Division of Forestry personnel in consultation with a Whittell Board representative. Prescribed fires will be conducted by NDF personnel or other qualified entities expressly approved by NDF/UNR.

The proposed treatments are needed to reduce the risk of catastrophic, stand-replacing wildfire such as the 1981 ‘Little Valley’ fire, which actually burned to the south and east of Little Valley, and the 2004 ‘Waterfall’ fire west of Carson City. These treatments will also decrease the threat of wildfire to property and homes in Washoe Valley, while increasing ecosystem health in the Whittell Forest.

Introduction

In December 1959, George Whittell donated 2650 acres of land in the Carson Range to the University of Nevada. This land, now known as the George Whittell Forest and Wildlife Area (Fig. 1), is on the western edge of Washoe Valley ≈32 km south of Reno, Washoe County, Nevada (39° 14'-17' N, 119° 52'-53' W). Most of the Whittell Forest is in Little Valley, which is ≈10 km long and 3 km wide and is separated from the Lake Tahoe Basin (5 km to the southwest) by a high ridge (≈2700 m) along the west side.

In August 1961, the Board of Regents of the University of Nevada System created the Board of Control at the University of Nevada, Reno "to supervise and control the area". In so doing, the Board of Regents mandated that "(1) most of the area shall be preserved as a Primitive Area for Research and (2) small and limited areas shall be designated as 'Class Use Areas' for experimentation and instruction". The Board was given authority to establish and enforce rules and regulations for the use of the area.

Since its establishment, the Whittell Board of Control has consisted of 6-15 University faculty, agency personnel and interested citizens who meet once or twice each year to discuss issues pertaining to the Whittell Forest and to develop policies for regulating activities in Little Valley. Current policies that have emerged since the 1960s include:

- Maintain roads to facilitate the teaching of University classes, the conducting of research, and the fighting of wildfires
- Maintain a fence line along the southern property boundary to exclude grazing by domestic livestock
- Vigorously exclude unauthorized vehicular travel by motorcycles, ATVs, automobiles and trucks
- Neither encourage nor discourage access by the public on foot, bicycles or on horseback
- Provide financial and logistical support for courses taught by faculty and graduate students of the Nevada System of Higher Education (NSHE)
- Encourage graduate student research in all disciplines by offering summer research fellowships
- Encourage faculty research in all disciplines
- Maintain a campground for use by University System students and faculty
- Minimize human impacts to natural plant and animal communities throughout the Whittell Forest
- Exclude firearms, hunting and trapping
- Promote cooperative interactions with state and federal government agencies to manage the greater Little Valley ecosystem

In keeping with the Regents' mandate, the Board has not instituted policies to manage forest resources. Although the wisdom of the current policy to maintain the Whittell Forest in a primitive state is widely appreciated by the students and faculty who use the valley, accumulation of fuels over recent decades exacergated by severe droughts in the 1990s has caused conditions in portions of the Whittell Forest to

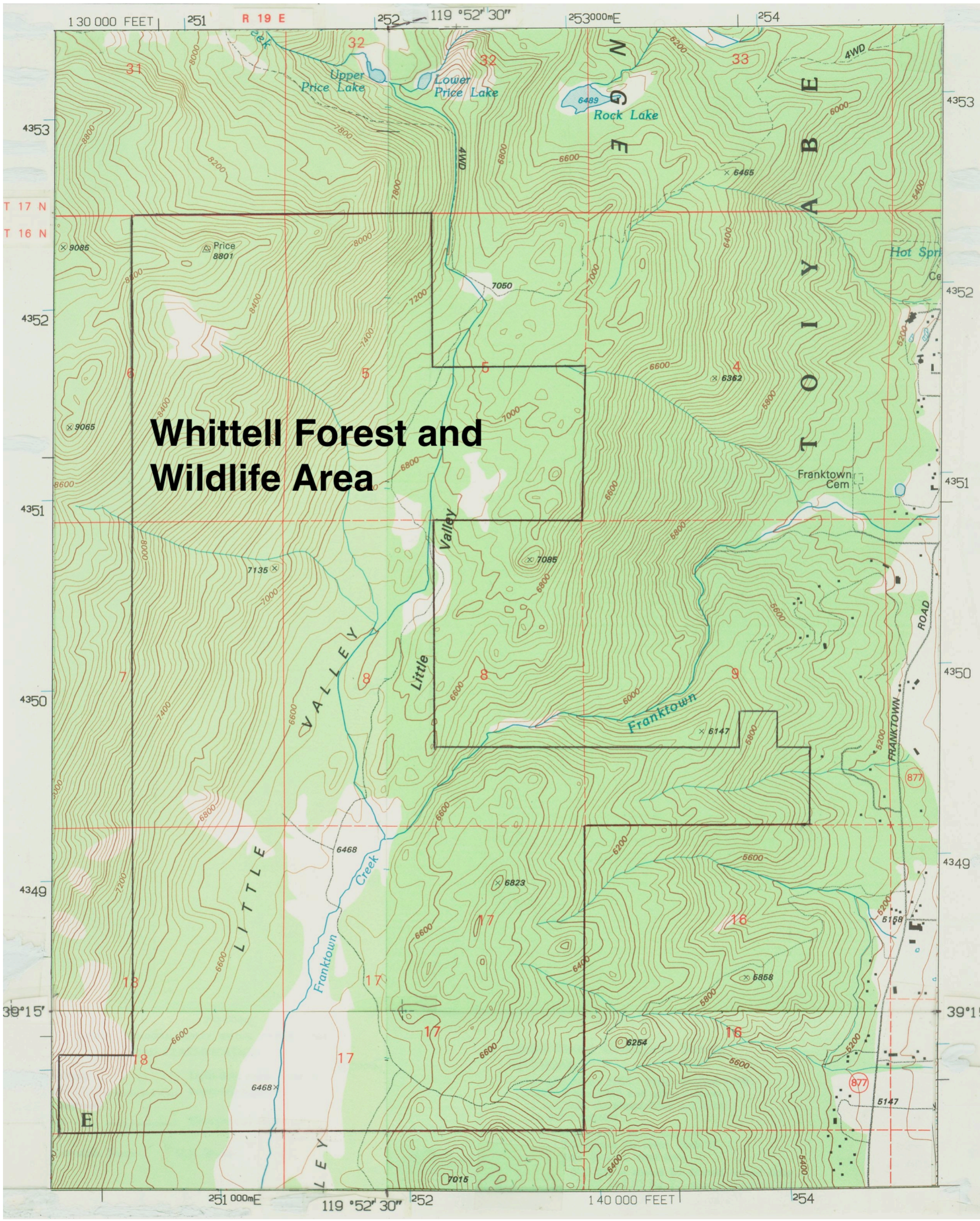


Fig. 1. The Whittell Forest and Wildlife Area. North is at the top.

deteriorate to the point that actions exceeding mere custodial care are deemed necessary. The situation in Little Valley reflects conditions experienced throughout nearly all similar forested ecosystems in the western United States. Extensive research has shown that the wildfire suppression policies practiced by federal, state, and private interests since the 1870s combined with inadequate vegetation management by land managers in fire's absence have caused fuel loads and fire risk in western forests, including portions of the greater Sierra Nevada ecosystem and the Whittell Forest, to reach crisis proportions. In response to this regional trend, and in the wake of several severe wildfires that have affected nearby areas in recent years, the Whittell Board proposes to adopt more proactive management policies.

In this document, the Whittell Board (representing the Nevada System of Higher Education) sets forth a plan to manage fuels in portions of the Whittell Forest to increase forest health and to reduce the risk of catastrophic wildfire in the Whittell Forest and Wildlife Area and adjacent areas. The plan is divided into two parts. In Part 1, we describe our general goals and objectives for managing the Whittell Forest and provide a context for the plan by describing the history, climate, and biotic resources of Little Valley. In Part 2, we describe a detailed plan of action and present a clear rationale for the plan.

PART 1 Ecological Context

Goals and Objectives of the Whittell Forest Fuels Management Plan

To attain the goal of producing a healthier, more fire resilient forest structure in Little Valley, the following ultimate objectives must be kept in mind.

1. To maintain the Whittell Forest as a 'primitive area' in perpetuity for research and teaching.

   We intend to manage so as to minimize the impacts of disturbance (other than that caused by prescribed fire) both from natural causes (e.g., catastrophic lightning-caused wildfire, bark beetle infestations) and anthropogenic causes (e.g., off-road vehicle use, public recreation, logging). We accept that these management objectives sometimes conflict with one another, which will require certain compromises. Achieving these objectives means that management options must be selected carefully. Many of the management tools commonly applied in other settings may not be appropriate in the Whittell Forest.

2. To reduce the likelihood of a catastrophic fire in the Whittell Forest.

   We plan to achieve this goal by reducing the amount of surface and ladder fuels, and by reducing stand density by removing saplings and small diameter trees. We expect that prescribed fire will play an important role in attaining these management objectives. We hope to achieve a more open, healthier forest that will be more resistant to catastrophic wildfire and to insect infestations.

3. To create a zone of defense within the Whittell Forest along which a wildfire could be fought and controlled.

   We plan to link treatment sites in a strategic way that will establish a front along which the risk of catastrophic fire has been greatly reduced and where a wildfire can be fought and controlled. It may take 5-10 years to establish such a zone, but once established, fire-fighting crews could operate within the zone to combat a regional fire.

4. To work closely with local, county, state and federal agencies to establish a network of sites that would facilitate the control of a wildfire.

   The zone of defense created in the Whittell Forest could be linked to other land area treatments on adjacent lands. For example, north of the Whittell Forest, the US Forest Service is planning fuel reduction treatments that could be contiguous with those conducted in the Whittell Forest. To the south, the US Forest Service and Nevada State Parks Department are planning other treatments. Together these linked areas could form a north-south front >9 km long that could play an important role in combating future wildfires in the Carson Range.

5. To maintain habitat diversity within the Whittell Forest.

   The meadow in Little Valley is being invaded by lodgepole pines and the riparian zone along Franktown Creek is also being crowded by lodgepole pines. Before Euro-American settlement, encroachment of pines onto the meadow was probably limited by the frequent occurrence of fires. Rehabilitating the meadow by removing small lodgepole pines will also contribute to a network of sites where catastrophic wildfire could be fought and controlled.

6. To improve wildlife habitat

   The improved forest health created by these treatments should increase the quality of habitat for many species, especially those dependent on old-growth forests, aspen stands, and riparian zones.

7. To monitor progress toward restoring forest health and reducing fuels

   It will be necessary to monitor the impacts of our management activities on fuel loads and forest health to ensure that our plan is meeting its goals. This management plan will create opportunities for research (many similar research and management efforts are occurring nationwide). Restoration is most successful where managers learn from their experiences and adjust their techniques over time (i.e., adaptive management). The Whittell Board should act to promote research on the effects of our management activities on biotic resources and the effectiveness of fuels management.

Regional Setting

The Whittell Forest is located in the rapidly growing Sierra Front of western Nevada. It lies within 15 km of the Truckee Meadows, which includes Reno and Sparks, with a population of 380,000 (in 2004). Less than 9 km to the southeast is Carson City with a population of 56,000. Washoe Valley, with a population of about 5,000, lies immediately to the east (Fig. 2). The population of the area as a whole has grown from 90,000 in 1960, about the time the Whittell Forest was established, to over 440,000 today.

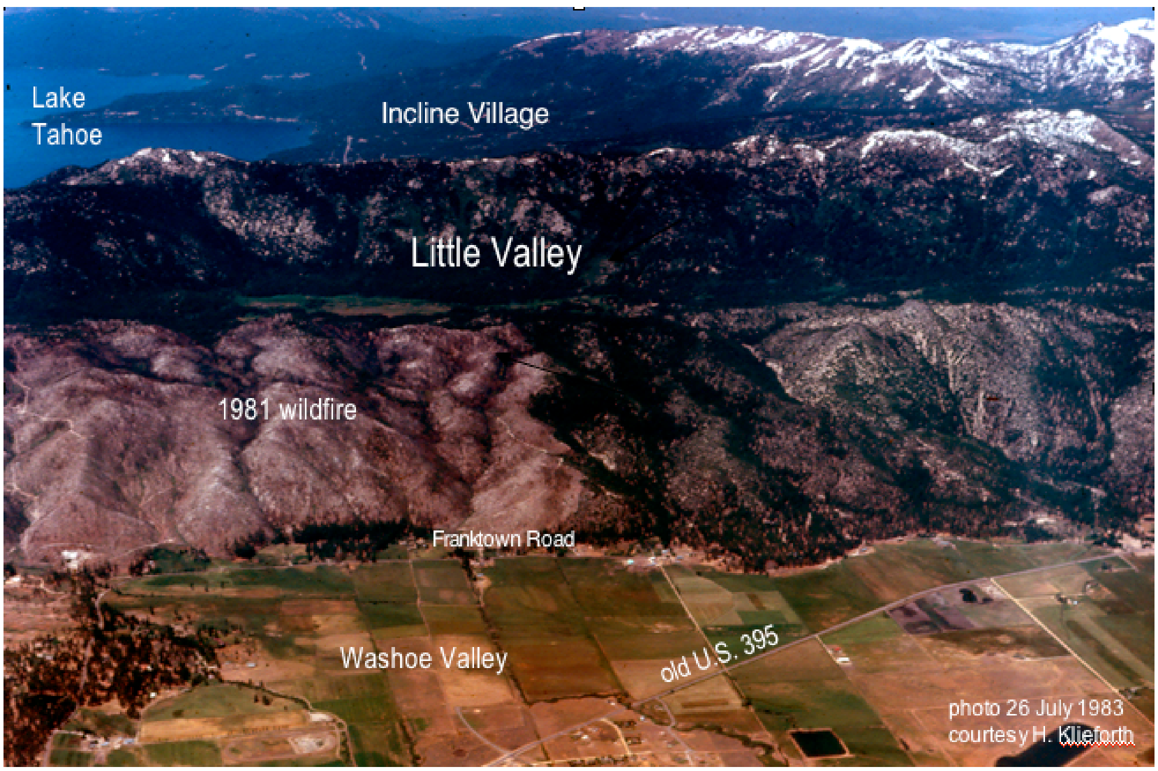


Fig. 2. Little Valley with Washoe Valley in the foreground and the northern Tahoe Basin in the distance.

The Whittell Forest is nearly surrounded by National Forest lands (93% of Whittell Forest perimeter) with some private lands to the southeast (7% of perimeter). Land uses in the area include recreation on National Forest lands. Most of the recreation uses are non-motorized. The Tahoe Rim trail to the west is a heavily used hiking and mountain biking route. Other popular routes are the Ophir Creek trail and the Tahoe Meadows/Price Lake trail to the north of Little Valley. Some motorized recreation occurs on National Forest lands on the south of the Whittell Forest. Lake Tahoe State Park, located 1.5 km south and west of the Whittell Forest in the Tahoe Basin, is a popular hiking, mountain biking, and camping area.

Other major recreation areas are Diamond Peak and Mount Rose Ski areas and Davis Creek and Bowers Mansion County Parks. All are located within 3 km of the Whittell Forest. The Tahoe Basin, which borders Little Valley to the west, has hundreds of thousands of visitors each year, but this area is separated from Little Valley by a ridge >800 m high, so very few of these visitors ever reach the Whittell Forest.

Private land uses in the region have been changing over time as ranch and other lands are being converted to residential uses. Fuel management policies on the Whittell Forest and adjacent National Forest lands are of great concern to local residents due to the history of wildfires in the area. In 2004, the Waterfall Fire burned 8700 acres west of Carson City. This fire burned in forest types similar to those in parts of the Whittell Forest. The fire burned into the southern part of Washoe Valley within three kilometers of the Whittell Forest. Seventeen houses were lost in that fire. The Little Valley fire of 1981 burned the slopes southwest of Washoe Valley, including ≈150 acres of the Whittell Forest. The actions outlined in this management plan are intended to minimize the risk of future fires and make the entire area safer for all who live near or use the area.

History of Little Valley

The Washoe and other native inhabitants of western Nevada are known to have followed a seasonal pattern of vertical migration from the lowlands of western Nevada to the Lake Tahoe Basin. During summers they moved into the Sierra to exploit resources available in the upland valleys and around the high lakes (Downs 1966). In 1965 Wilber Davis excavated three prehistoric sites in Little Valley, including a campsite on the east edge of the meadow, a bedrock mortar site in the southern end of the valley, and a surface scatter near the head of Franktown Creek. The materials found during these excavations included Elko-eared points from the Martis Complex (1000 B.C. – A.D. 600), Sierra stemmed triangular points associated with both the Martis Complex and the Kings Beach Complex (500 A.D. – historic period), and Desert side-notch points associated with the Kings Beach Complex. While the total number of artifacts recovered was small, the artifacts indicate that native peoples have utilized the resources of Little Valley seasonally for at least the last 3,000 years (Davis 1965).

The discovery of the Comstock Lode in 1859 led to the subsequent development of a large wood industry centered around Washoe Valley to supply fuel wood and timber to Virginia City (Ratay 1973). Some of the first European settlers in Little Valley (also known as White Rock Valley at the time) were loggers who arrived in the early 1860s. By 1863 two timber mills, the Read & Warlick and the Woodward & Hammond, were operating in Little Valley supplying the mines, ore mills and towns of the Comstock mining enterprise. Oliver Lonkey, a French-Canadian lumberman, moved a steam engine to Little Valley in 1863 and constructed a sawmill near the head of Franktown Creek at the northern end of the valley. These and other mills led to the construction of an extensive network of logging roads and camps in the valley. During this period, logs were brought to the mills by ox cart and dry log chutes were built on the steeper slopes. In 1863 Lonkey and John Stockman purchased the Woodward & Hammond Mill near the confluence of the north and south forks of Franktown Creek. Lonkey's Mill employed 25

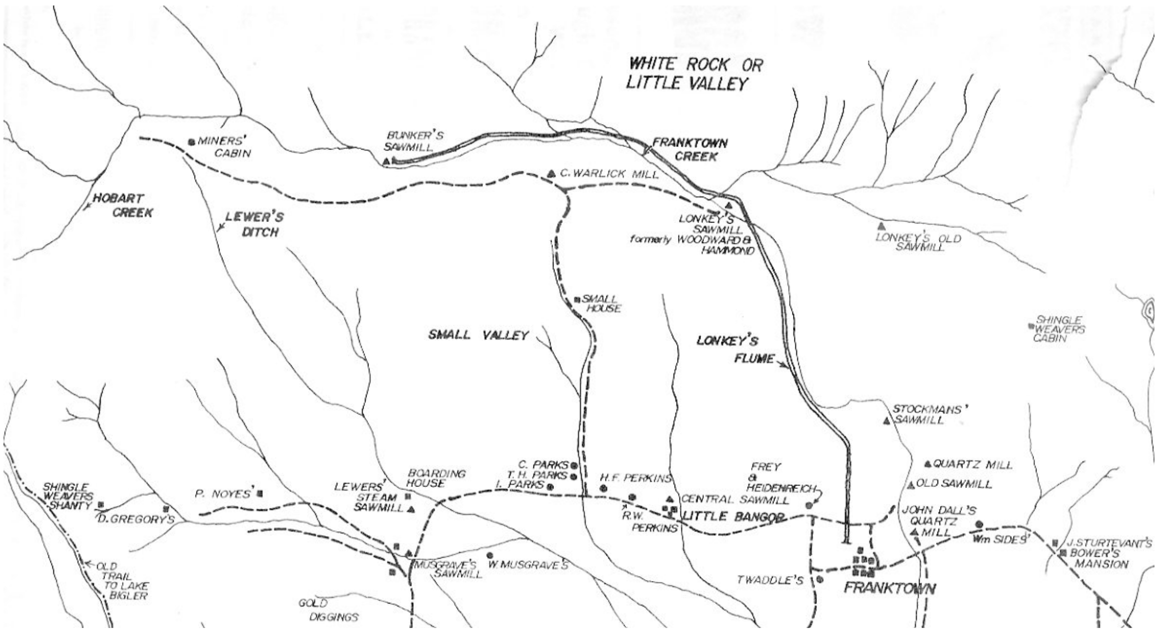


Fig. 3. Portion of a map titled “Early Washoe Valley” (undated) from Ratay (1973). Note Franktown Creek in Little Valley, Bunker’s Sawmill, Warlick Mill, Lonkey’s Sawmill, Lonkey’s Old Sawmill, Lonkey’s Flume, the road into Little Valley, and the settlements on the west side of Washoe Valley.

men and produced 2 million board feet of lumber per year (Ratay 1973). In 1864 Lonkey constructed the first “V” flume in the valley to carry waste away from his mill. In 1870 he began construction of a 4-km long flume to carry cordwood and milled lumber from his mill and the old Read & Warlick Mill (which had been sold to Nathanial Bunker) in Little Valley down Franktown Creek to Washoe Valley (Fig. 3). In 1872 Lonkey sold his mill and flume to J. W. Haynie, H. M. Yerrington, and A. J. Ralston, who were associated with the Bank of California. That same year the Virginia and Truckee Railroad built a rail spur to the end of the Little Valley Flume near Franktown, which greatly increased the efficiency of transporting lumber and cord wood to Virginia City. In 1873 General W.S. Hobart and Walter Marlette established the Excelsior Mill in the southern end of Little Valley and built another flume to Washoe Valley. Driven by the Comstock mine’s insatiable demand for lumber, Little Valley was nearly logged out by 1875. Small-scale logging continued until 1880, but the major mills were abandoned or moved to sites that had fresh timber. The depletion of reserves for the timber industry triggered a rapid decrease in domestic habitation in Little Valley.

In 1871 the Gold Hill Water Company acquired part of Little Valley along with the water rights to Franktown Creek and began construction of a flume to supply water to Virginia City. This triggered a flurry of lawsuits from ranchers in Washoe Valley who claimed the water, and in 1880 the water company gave the ranchers permission to dam the head of Franktown Creek and to turn a portion of Little Valley into a reservoir (Ratay 1973). Heavy rains in late January 1881 filled the reservoir faster than anyone had

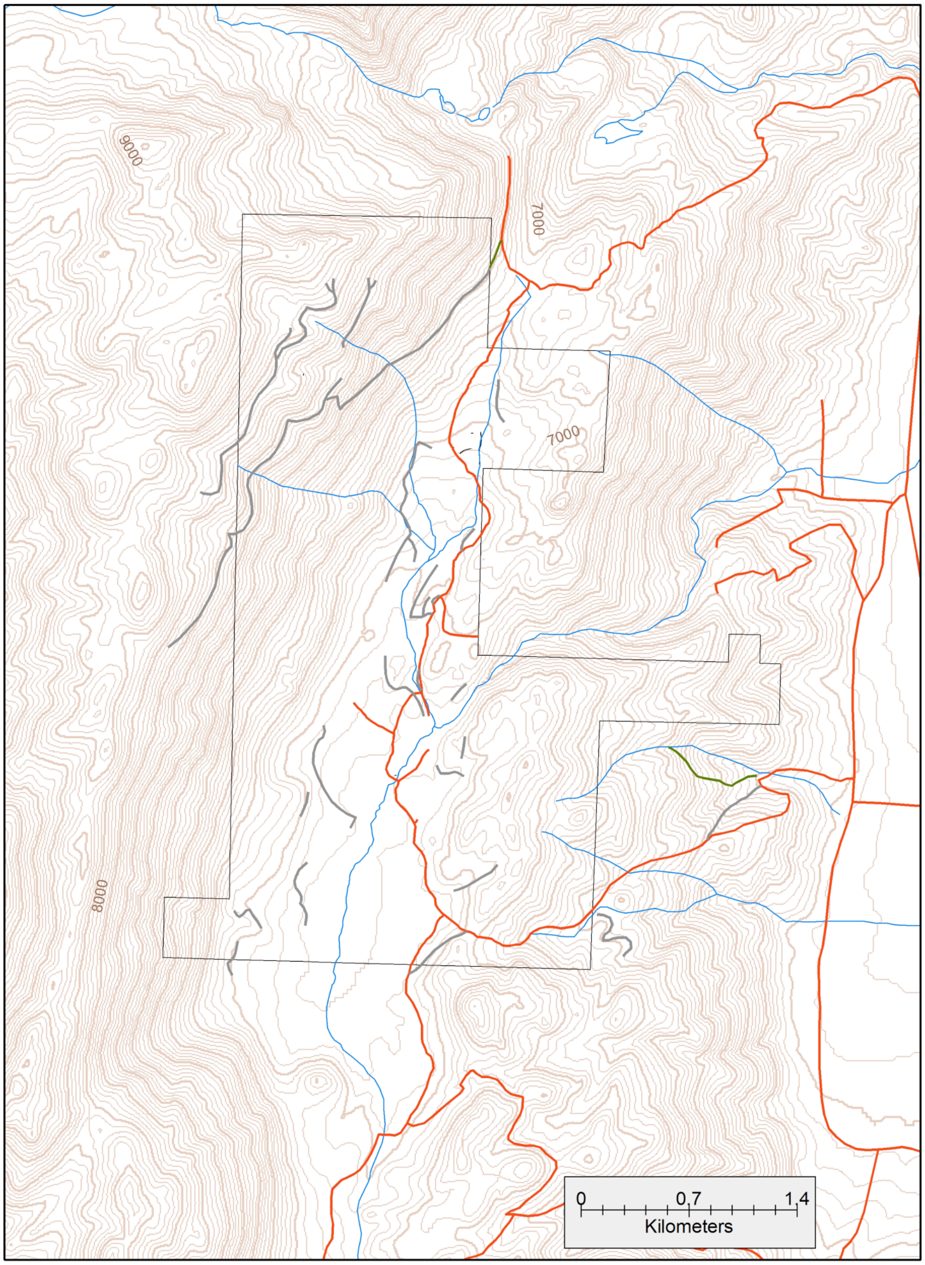


Fig. 4. Roads and ditches in Little Valley. Modern roads in red, historic roads in gray, historic ditches in green. Blanchard, 2005 archaeological survey.

thought possible. A floodgate that was designed to release excess water jammed, and despite the efforts of workmen it could not be opened. On 2 February 1881, the poorly constructed earthen dam failed, releasing millions of gallons of water into Franktown Creek. A wall of water tore down Franktown Canyon, scouring the canyon bottom and flooding the community of Franktown, neighboring ranches, and the railroad line in Washoe Valley 4 km below the dam.

From 1881 to the 1970s, Little Valley was used for sheep and cattle grazing by ranchers from Washoe Valley. From the 1890s through the 1950s, heavy grazing turned Little Valley into a "dustbowl." Shortly after the University took control of the Whittell Forest in 1959, the Whittell Board resolved to eliminate grazing. Since the mid 1960s, the Whittell Board has maintained a fence along the southern boundary of the property to prevent domestic stock from straying onto University property from adjacent federal lands. Cattle grazing was discontinued on US Forest Service lands south of University property in about 1999.

During the summer of 2005, Morgan Blanchard (with the assistance of Hal Klieforth, Donald Hardesty and Stephen Vander Wall) identified and mapped historic (Comstock era) roads in Little Valley (Fig. 4). During the survey, a number of archaeological sites were also encountered and mapped. From their proximity to archaeological sites associated with mid 19th century logging and milling sites (identified by Blanchard in 2005 and by Hardesty during excavations between 1972 and 1974) and their placement and mode of construction, it is probable that the majority of roads in Little Valley (including many of the roads currently in use) were built between 1860 and 1880. However, no primary historical documentation has been discovered concerning their construction or historic use. In general, the historic roads are inconspicuous, fragmentary and in many places obscured by thick vegetation and downed timber.

Climate

The climate of Little Valley, like that of the Sierra Nevada and most of California, is mediterranean. The distinguishing features of a mediterranean climate are warm, dry summer conditions, usually beginning in late May and lasting through October, and cool, wet winters. The summer dry season in Little Valley results from the establishment of the North Pacific High, a high-pressure anticyclone that directs most Pacific storms northward into Canada. This season is characterized by sunny weather punctuated with a few intense thunderstorms of short duration, usually associated with monsoonal flows moving northwest out of the Gulf of California or north out of the subtropical eastern Pacific. Consequently, dry conditions prevail for most of the summer, interrupted by wet conditions that usually last only a few days. Winters, on the other hand, are characterized by prevailing westerly airflow that brings moist cyclonic storms from mid-November through May.

Mean annual precipitation at the weather station in Little Valley (1993 m) is 87.5 cm. As is generally the case in arid environments, there is large interannual variation in precipitation. Annual precipitation in Little Valley varies from ≈50% to ≈200% of the mean. Little Valley (like all of western Nevada) has experienced two severe droughts in recent years: 1986-1992 and 2000-2004 (Fig. 5). At the Cliff Ranch on Franktown Road

(1585 m), ≈25% of the average annual precipitation falls as snow. In Little Valley the figure is ≈50%, and at Tahoe Meadows (2600 m) >85% of precipitation is snow. Lake Tahoe influences precipitation in Little Valley in late fall and early winter when cold, maritime polar air masses absorb moisture from the relatively warm water, creating lake-effect snows. The heavy precipitation that falls on the higher elevations of the ridge west of Little Valley, and the spring runoff from that snowpack, helps support the extensive pine and fir forests and the riparian areas of Little Valley.

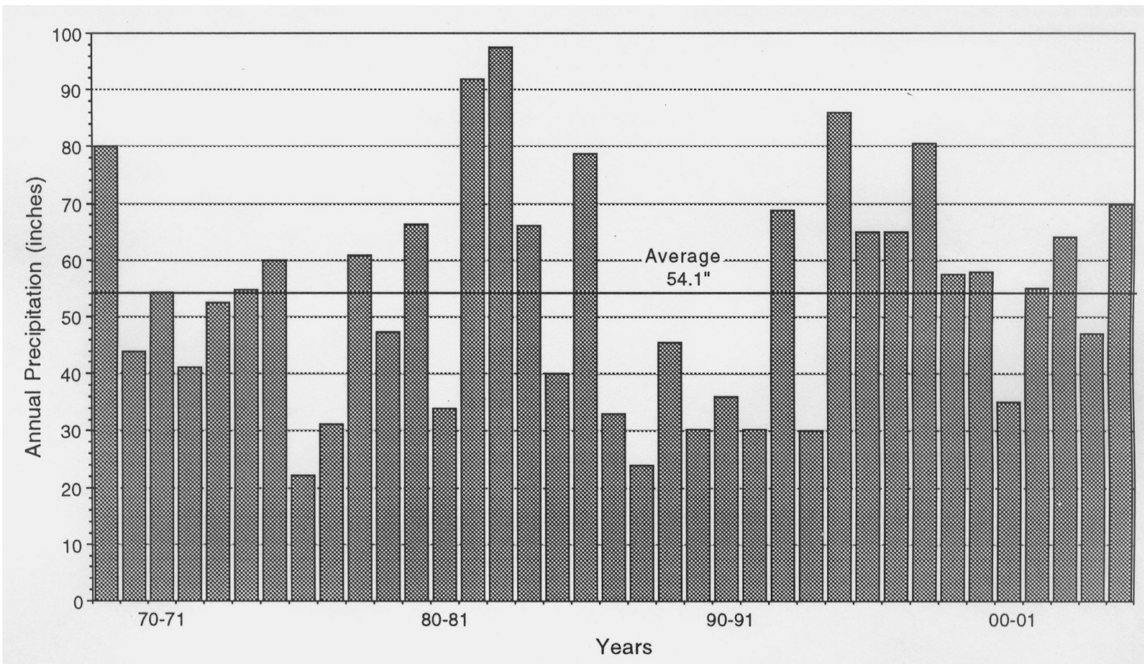
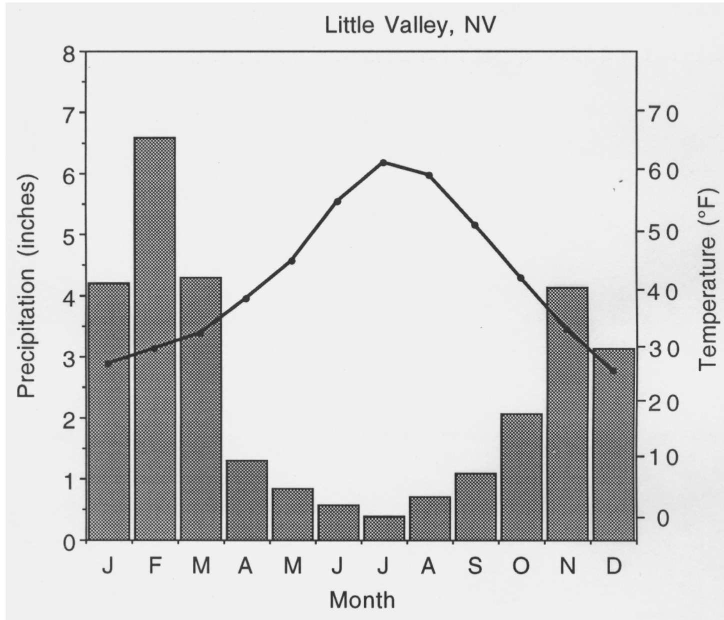


Fig. 5. Annual precipitation at Tahoe Meadows (≈6 km north-northwest of Little Valley at an elevation of 2600 m). Precipitation years are calculated from 1 July to 30 June.

Temperatures in Little Valley are cool relative to those of the Great Basin Desert to the east. Mean monthly temperatures in Little Valley range from ≈51-61°F during summer and ≈25-33°F during winter (Fig. 6). Daily variation in temperature during summer, from daytime highs to nighttime lows, is often 40-50°F. The most extreme temperatures recorded from 1965 to 2005 were 92°F and -35°F. In winter, rare invasions of arctic air masses can result in periods of prolonged sub-freezing temperatures.

During the warmer half of the year, winds show a pronounced diurnal pattern: calm to easterly breezes in the morning become westerly in the early afternoon with a maximum speed of 20-25 mph, diminishing near sunset. Most summer and autumn days have no noticeable wind. Preceding cold fronts during winter, wind speeds can exceed 60 to 80 mph over ridges and in Little Valley.

Fig. 6. Weather chart for Little Valley based on 22 years of data gathered at the Little Valley weather station (1993 m) by Hal Klieforth. Bars are mean monthly precipitation; the line is mean monthly temperature.



Relative humidity is lowest (often 5-10%) during summer days accompanied by downslope winds. Because relative humidity varies with both actual humidity and air temperature, relative humidity usually increases at night as the temperature falls, often approaching or reaching 100% just before dawn.

The mountainous terrain has a major influence on the climate, especially on the temporal and spatial patterns of air temperature, wind, cloud types, and precipitation. Factors such as elevation, slope, aspect, geomorphology, hydrology, and soil type contribute to local climate variation that accounts for the broad range of life zones and plant associations found in Little Valley (see *Vegetation*).

Weather can have an important effect on the intensity and rate of spread of fire. Lightening from thunderstorms is the primary non-anthropogenic cause of fires. Thunderstorms, which do not necessarily result in much precipitation, occur most frequently on warm summer days, which are also characterized by low fuel moisture, low relative humidity and strong winds. Under contemporary conditions (i.e., heavy fuel loads), fire can quickly ascend into the forest canopy and become a crown fire. Dry, windy conditions can drive the flames into a conflagration. These conditions, coupled with the fact that daylength is ≈15 hours long, make it difficult to extinguish a summer wildfire. In contrast, prescribed fires are typically conducted in the late autumn (or early spring), after one or more fall storms, when vegetation moisture content is relatively high, air is cool, relative humidity is higher, winds are mild, and days are short (≈10-11 hours). These conditions, and the careful preparation of fire breaks and manipulation of fuels by personnel before conducting a prescribed burn, make it much easier to control a prescribed fire.

Terrestrial Ecosystems of Little Valley

Soils

Soils of Little Valley are primarily of granitic origin, but there is a small intrusive body of basalt on the northwestern side of Franktown Creek. The granitic soils of the uplands mostly fall into the Inceptisol (suffix –epts) and Entisols (suffix –ents) soil orders. These soils are characterized by poor profile development and low fertility, a result of their generally coarse texture and colluvial activity. Specific soil series and classifications include the Marla series (sandy, mixed, Aquic Cryumbrepts), which occur on alluvial fans and are characterized by moist conditions with lodgepole pine dominating the overstory vegetation; the Corbett series (mixed, frigid, Typic Xeropsamments) which occur on mountain sideslopes with Jeffrey pine as the typical dominating overstory vegetation; the Toiyabe series (mixed, frigid, shallow Typic Xeropsamments) which occur on mountain ridges with Jeffrey pine as the typical dominating overstory vegetation; the Temo series (mixed, shallow Typic Cryopsamments), bouldery and sandy soils occurring on 30-50% slopes on the west side of the valley, with Jeffrey pine, white fir, and red fir overstory vegetation; and the Witefels series (mixed, Typic Cryopsamments) occurring on mountain sideslopes on the west side of the valley with Jeffrey pine, white fir, and red fir overstory vegetation.

Soils in and near the meadow and on stream terraces include those of the Alfisol (suffix –alfs) and Mollisol (suffix –olls) orders, which are characterized by higher organic matter content and greater fertility. These soils include the Inville variant series (loamy-skeletal, mixed, frigid, Aquultic Haploxeralfs), occurring on 2-8% slopes in lowland areas near the meadow with lodgepole pine as dominant overstory vegetation, the Apmat series (loamy-skeletal, mixed, frigid Ultic Argixerolls), located on stream terraces with Jeffrey pine as dominant overstory vegetation, and the Blackwell series (fine-loamy, mixed, Typic Cryaquolls), which are located within the meadow and are dominated by willows and sedges.

Fire normally causes a short-term increase in soil ammonium and sometimes causes increases in calcium, potassium, magnesium, and pH (Neary et al., 1999). Effects of fire on available phosphorus are mixed – sometimes increasing it, sometimes decreasing it, sometimes having no effect. Only very severe fires cause loss of total organic matter and organic nitrogen (N). By far the greatest long-term effect of fire is the loss of nitrogen from burned organic matter (mostly plant foliage and ground and surface fuels) by volatilization (Raison et al., 1985). Unless replaced by fixation, fertilization, or high levels of air pollution, fire can cause long-term losses of soil fertility because of the N loss (Johnson et al., 2004). Also, the cumulative effects of repeated prescribed fire can cause greater long-term N losses than a single wildfire because recurrent N losses every 5-20 years add up, and fires that occur at short intervals can slow the recolonization of nitrogen-fixing plants such as tobacco brush (Johnson et al. 1997, 1998).

Decomposition of organic matter in Little Valley forests is typically very slow and occurs primarily beneath the winter snowpack, despite low temperatures, because the litter is too dry during the snow-free portion of the year for significant decomposition to occur (Stark, 1973). In general, net primary productivity in Jeffrey pine and lodgepole pine forests exceeds the rate of decomposition, resulting in the gradual accumulation of organic matter (i.e., fuels) (Fig. 7).

Fig. 7. Snow melts faster around trees during winter, causing the soil to dry out sooner and slowing the rate of decomposition of organic matter. The accumulated plant litter causes the ground to rise slightly near the base of the tree.

Vegetation

Table 1 shows how the Whittell Forest acreage is partitioned into 9 vegetation types based on characteristics of the plant communities. Fig. 8 shows the distribution of these vegetation types. Nearly 85% of the area is occupied by forest habitat; the rest comprises shrub, meadow and riparian communities. A brief description of vegetation types follows. Plant species known to occur in and near the Whittell Forest are listed in Appendix 1.

Table 1. Major vegetation types of the Whittell Forest

Vegetation type	Map color	% of WFWA	Acreage (ha)
Jeffrey pine-white fir forest	Green	66.8	1768.2 (715.5)
Lodgepole pine forest	Light green	9.3	247.2 (100.1)
Red fir-subalpine forest	Dark green	8.0	213.0 (86.2)
Aspen	Yellow	0.5	12.4 (5.0)
Riparian	Blue gray	3.6	96.0 (38.9)
Montane shrub	Dark brown	7.1	188.1 (76.2)
Dry meadow	Light brown	3.1	82.3 (33.3)
Wet meadow	Brown	1.2	31.9 (12.9)
Wyethia meadow	Orange	0.4	10.9 (4.4)

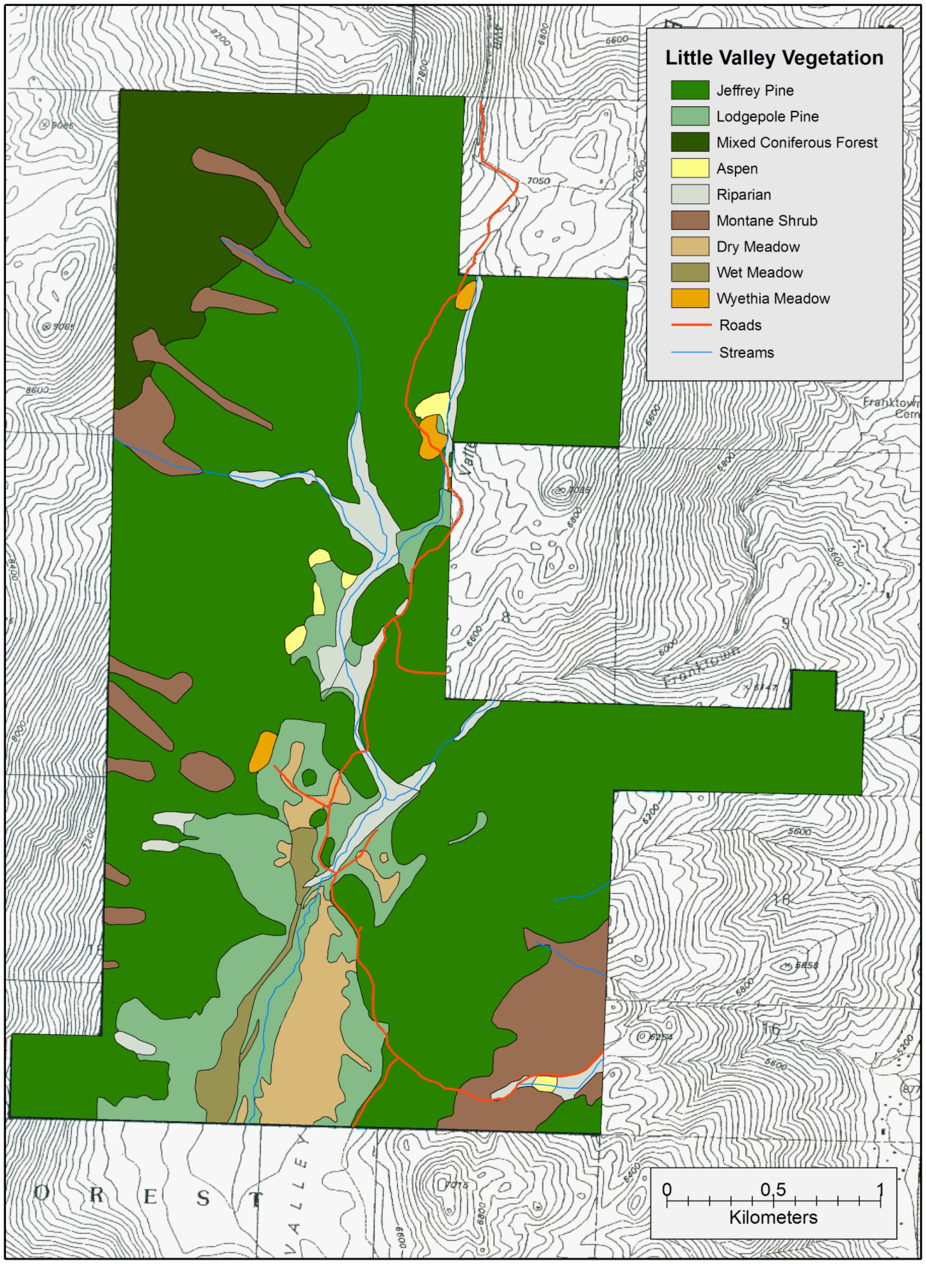


Fig. 8. Vegetation of the Whittell Forest. North is at the top. See Table 1 for further information.

Jeffrey pine-white fir forest – Jeffrey pine-white fir forests dominate the slopes of Little Valley below ≈2500 m on well-drained, granitic soils. Jeffrey pine (*Pinus jeffreyi*) often intergrades with lodgepole pine forests, which typically occur on slightly lower sites with heavier soils that retain more moisture following spring runoff. White fir (*Abies concolor*) is a minor but consistent component of these forests, comprising <5% of mature trees. Other tree species that occur in this plant community include ponderosa pine (*Pinus ponderosa*) below ≈1700 m, incense cedar (*Calocedrus decurrens*) below ≈1825 m, and sugar pine (*Pinus lambertiana*) between 1700 and 1850 m. The densityand understory of this forest type is highly variable. Approximately 50% of this habitat is open with well-spaced trees (Fig. 9), a well-developed shrub community consisting or antelope bitterbrush (*Purshia tridentata*), greenleaf manzanita (*Arctostaphylos patula*), tobacco brush (*Ceanothus velutinus*) and Sierra bush chinquapin (*Castanopsis sempervirens*), and large expanses of exposed mineral soil with scattered boulders. The other 50% has greater canopy closure. In these forests, mature trees can be moderately to very crowded and the understory is shady, with few shrubs, thick accumulations of plant litter, and little exposed mineral soil. Common wildflowers in Jeffrey pine-white fir forests include common Indian paintbrush (*Castilleja miniata*), showy penstemon (*Penstemon speciosus*), pride of the mountain (*Penstemon newberryi*), and pine pedicularis (*Pedicularis semibarbata*).

Fig. 9. Open Jeffrey pine forest with an understory of antelope bitterbrush.

Lodgepole pine forest – This forest is dominated by lodgepole pine (*Pinus contorta)* with small amounts of Jeffrey pine and white fir. It occurs on the lower slopes of the valley on heavy, poorly-drained soils. Lodgepole pines occur most noticeably and at high density along the margins of the meadow and have been encroaching on the meadow since the mid 1960s when grazing was discontinued (Fig. 10). Older stands of lodgepole pine are often crowded with substantial quantities of downed, woody debris. Important understory shrubs include serviceberry (*Amelanchier pallida*) and blue currant (*Ribes cereum*). Wildflowers include monkshood (*Aconitum columbianum*), alpine lily (*Lilium parvum*), and water plantain buttercup (*Ranunculus alismifolius*).

Fig. 10. Lodgepole pine forest along the meadow edge.

Red fir-mixed subalpine forest – This forest type occurs above ≈2500 m in the northwestern corner of the Whittell Forest. Jeffrey pines become less common at elevations above 2500 m, being replaced by western white pine (*Pinus monticola*), red fir (*Abies magnifica*), whitebark pine (*Pinus albicaulis*), and mountain hemlock (*Tsuga mertensiana*) as the elevation increases to ≈2700 m. The forest is generally very open with a sparse shrub understory and a high proportion of exposed, mineral soil (Fig. 11). Net primary productivity in these high elevation forests is lower and rates of decomposition are greater, so that less downed, woody debris is present than in lower elevation forests. The shrub understory consists of tobacco brush and pine mat manzanita (*Arctostaphylos nevadensis*). The red fir-mixed subalpine forest is also characterized by being steep and remote from the existing road network in Little Valley.

Fig. 11. Red fir-mixed subalpine forest along ridgetops and on steep slopes above 2500 m in the northwest portion of the Whittell Forest.

Aspen forest – Quaking aspen (*Populus tremuloides*) groves are not very numerous in Little Valley, comprising only 6 small stands (Fig. 12). Aspen stands are rejuvenated by stand-replacing fires (DeByle et al. 1987). Except for a small stand that experienced the 1981 fire on the east slope of the Whittell Forest, stands in Little Valley are over-mature and are being invaded by lodgepole pine and white fir. Despite their dependence on fire for rejuvenation, aspen stands are not highly flammable (DeByle et al. 1987). Large, uninterrupted stands of aspen can serve as effective firebreaks.

Fig. 12. Aspen forest. Note the white fir saplings that invade if this habitat is not periodically burned.

Montane shrub – The 1981 “Little Valley” fire didn’t actually affect Little Valley much but burned to the east and south toward Carson City. Most of the burned area is now a shrub community (chaparral) dominated by greenleaf manzanita, tobacco brush, Sierra bush chinquapin, and antelope bitterbrush (Fig. 13). Jeffrey pines are slowly invading this habitat. Many young saplings that established soon after the fire are now tall enough to be visible above the dense shrub layer. Montane shrub communities are early seral stages that are dependent on disturbance for their creation and persistence. Elsewhere in the Whittell Forest, montane shrub habitat is most commonly found in avalanche chutes along the west side of the valley. Avalanches occur infrequently; the most recent was in February 1986 when several days of heavy, wet snowfall at high elevations caused massive avalanches in the Carson Range. At these higher elevation sites, the dominant shrubs are tobacco brush and bitter cherry (*Prunus emarginatus*).

Fig. 13. A portion of the 1981 “Little Valley” fire. The shrub community is dominated by manzanita and tobaccobrush. Note the Jeffrey pine logs and saplings.

Riparian -- There is a narrow riparian zone along Franktown Creek consisting of willows (*Salix* spp.), alder (*Alnus tenuifolia*) and scattered aspens. This habitat is most well developed near the confluence of the north and south branches of Franktown Creek and along lower reaches of the north fork of Franktown Creek (Fig. 14). In the southern portion of the Whittell Forest, the riparian habitat is being crowded out by encroaching lodgepole pines. The mountain bluebell (*Mertensia ciliata*) and prairie lupine (*Lupinus sellulus*) are common wildflowers.

Fig. 14. Riparian vegetation (willows) along Franktown Creek with the crest of the Carson Range on the west side of Little Valley in the background

Dry meadow – The meadow on the east side of Franktown Creek (Fig. 15 and frontis piece) and at slightly higher elevations on the west side of the creek in the vicinity of the campground dries out during the summer. Vegetation in this dry meadow is dominated by grasses and forbs with scattered low sagebrush (*Artemisia arbuscula*). Lodgepole pines have invaded this habitat (starting in the mid 1960s when grazing was terminated) especially along the banks of the south fork of Franktown Creek. Common wildflowers include blue camas (*Camassia quamash*), meadow penstemon (*Penstemon rydbergii*), Nuttall's larkspur (*Delphinium nuttallianum*), Sierra onion (*Allium campanulatum*), prairie lupine, and American bistort (*Polygonum bistortoides*).

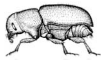
Fig. 15. The dry meadow in Little Valley in spring. The flower is blue camas (*Camassia quamash*).

Wet meadow – The meadow in the southwestern portion of the valley (west of Franktown Creek) remains wet throughout the summer (Fig. 16). This is because numerous springs on the west slope of the valley deliver groundwater (from the winter snowpack) to the valley bottom even in the driest years. Vegetation in this habitat is dominated by rushes (*Juncus* spp.) and sedges (*Carex* spp.) with scattered willows. Alpine shooting star (*Dodecatheon alpinum*) is a common wildflower.

Fig. 16. Wet meadow habitat dominated by tall grasses and sedges with scattered willows.

Wyethia meadow – Jeffrey pine forest openings dominated by mule-ears (*Wyethia mollis*) have been created by years of intense overgrazing by sheep (Yoder-Williams and Parker 1987). A relatively small area of Little Valley has been so affected, but these areas are ecologically interesting. *Wyethia* produces secondary compounds that are toxic to sheep and deter them from grazing, which appears to account for why this plant eventually dominates the heavily over-grazed sites. When the leaves decompose during winter, the secondary compounds are released into the soil and inhibit the germination of other plant seeds during spring (Yoder-Williams and Parker 1987). Scattered bitterbrush and young Jeffrey pines are gradually invading these sites, but the rate of succession is very slow (Fig. 17). Wildflowers include sego lily (*Calochortus nuttallii*) and western peony (*Paeonia brownii*).

Fig. 17. This *Wyethia* meadow was probably created in the 1930s from years of severe over-grazing by sheep.



Bark beetles

Bark beetles (Coleoptera: Scolytidae) are the most destructive insect pests in Little Valley. Three species of bark beetles attack and kill live coniferous trees in Little Valley and a fourth species colonizes recently fallen trees and branches. Lodgepole pines become susceptible to attack by the mountain pine beetle (*Dendroctonus ponderosae*) when they are stressed by drought. Unlike *D. ponderosae*, which can attack trees other than lodgepole pine, the Jeffrey pine beetle, *D. jeffreyi*, is monophagous on Jeffrey pines, usually attacking those trees weakened by drought and/or crowding. Where ponderosa pines are present, *D. ponderosae* and *D. brevicormis* are potential problems, but ponderosa pines occur only on the eastern edge of the Whittell Forest (i.e., not in Little Valley proper). At high elevations in Little Valley (2100 to 2250 m), there is only one generation of mountain pine beetle and Jeffrey pine beetle each year. White and red firs are periodically attacked by the fir engraver beetle (*Scolytus ventralis*). A fourth species of bark beetle, the pine engraver beetle (*Ips pini*), primarily attacks slash and downed trees. Several other species of beetles can be found in Little Valley at times, often associated with trees under attack by the three aggressive species.

Forests in Little Valley, as in most western states, undergo periodic outbreaks of beetle attacks. The extended drought from 1986-1994 triggered massive attacks by all three species of aggressive beetles on drought-stressed trees, and resulted in major losses of Jeffrey and lodgepole pines and white fir. Extensive death of lodgepole pines occurred along Franktown Creek in the southern half of the valley and south of the road leading to the campground. There are currently several small infestations of mountain pine beetles on the southwest part of Little Valley, west of Franktown Creek and along the east side of the meadow. Starting in about 1990 and extending through 2001, Jeffrey pine beetles killed a number of mature Jeffrey pines along and east of the main road through the valley. As drought conditions improved, beetle populations began to dwindle and, consequently, few trees have been killed by Jeffrey pine beetles in Little Valley in the last four years. In the early 1990s, fir engraver beetles began attacking white firs on the steeper slopes along the west side of Little Valley. Most of the damage was done by the mid 1990s, and no new attacks have occurred since about 2000. However, the pine engraver beetle continues to attack green, wind-thrown branches and recently felled lodgepole and Jeffrey pines. It is the unusually high fuel loading caused by many of these dead trees falling in the last few years that has stimulated the need for action and fuel reduction in the Whittell Forest (Fig. 18) (this pattern has been repeated in many other areas in the west).

Healthy, widely spaced trees with access to sufficient water are usually able to defend themselves from bark beetles by using sap to 'pitch-out' the attacking beetle (Fig. 19). When trees are compromised by drought or disease, however, they do not fare as well against these insect pests. A pioneer beetle initiates a mass attack on a host tree by producing a volatile 'aggregation' pheromone that coordinates mating and host colonization (Wood 1982). In the mountain pine beetle, the female pioneer uses a blend of exo-brevocomin, frontalin and verbenol as an aggregation pheromone. Female

Fig. 18. A cluster of Jeffrey pine trees that have been killed by pine bark beetles.

Fig. 19. A pitch tube on lodgeple pine. As the beetle burrows into the bark, the tree attempts to eject it with pitch. The yellow color is insect feces, indicating that the beetle successfully entered this tree.

Jeffrey pine beetles use 1-heptanol, the hydroxylated product of host-tree-produced heptane, along with tree volatiles to attract conspecifics (Borden 1985). In the pine engraver beetle, male pioneers use ipsdienol as a major pheromone component (Borden 1985).

Male and female beetles are attracted to a new host tree by these airborne pheromones and, once there, they mate beneath the bark (Wood 1982). Following mating, females lay eggs at the margins of feeding galleries, which develop into larvae, and eventually pupae and then teneral adults. The larvae feed on the nutrient-rich phloem, compromising the vascular system of the tree. Additionally, beetles introduce a 'blue stain' fungus (*Ophiostoma minus*) (Fig. 20) that grows into the xylem and inhibits water transport (Paine et al. 1997). The detrimental effects of corporate feeding by the larvae and the 'blue stain' fungus combine to effectively kill a tree.

The destructive nature of these aggressive beetles is exacerbated by difficulty in controlling their populations. Because they spend the majority of their lives concealed beneath the bark of trees, bark beetles are physically protected from sprayed pesticides.

Moreover, the goal of maintaining the Whittell Forest as a ‘primitive area’ favors conditions that facilitate beetle attacks. The crowded conditions that prevail in many stands of trees in Little Valley unduly stress trees, making them more susceptible to bark beetle attack during drought conditions. Work is currently underway in Little Valley by UNR faculty and graduate students to gain a better understanding of pheromone production in bark beetles (Hall et al. 2002a, b, Tittiger et al. 2003, Nardi et al. 2002, Keeling et al. 2004, Tillman et al. 2004, Gilg et al. 2005)

Fig. 20. ‘Blue stain’ fungi in a pine log introduced by pine bark beetles. The fungi help kill the tree and hasten decomposition of the wood.

Mammals

With regard to forest regeneration, the most important mammals in the Whittell Forest are the rodents that consume and disperse pine seeds. By foraging for pine seeds, these animals inadvertently influence the reproduction of pines, sometimes negatively and sometimes positively. Successful establishment and growth (recruitment) of seedlings and saplings is essential to the maintenance of a healthy forest, but in the absence of fire and other types of disturbances, a forest can become overstocked with young trees, which can result in thickets of slow-growing trees and which adds to ladder fuels.

Rodents facilitate the establishment of pine trees by gathering seeds and caching them in soil. In the Whittell Forest, four pines are dispersed in this manner: Jeffrey pine, ponderosa pine, sugar pine and whitebark pine (Tomback 1989, Vander Wall 1992, 2002, 2003, Thayer and Vander Wall 2005). A number of rodents are engaged in these activities, but the most important are yellow pine chipmunks *(Tamias amoenus*), long-eared chipmunks (*Tamias quadrimaculatus*), deer mice (*Peromyscus maniculatus*), and golden-mantled ground squirrels (*Spermophilus lateralis*) (Vander Wall et al. 2001, Briggs et al. in prep.). Among these mutualistic plant-animal interactions, the most important is that between Jeffrey pine and yellow pine chipmunks (Fig. 21). This is because Jeffrey pine is the dominant tree species in the Whittell Forest and because yellow pine chipmunks are the most common rodents in Little Valley. Furthermore, the caching behavior of yellow pine chipmunks makes them very effective dispersers of these pines (Vander Wall 1992, 1993, 2002a, b, Vander Wall and Joyner 1998). Chipmunks (and other rodents) gather pine seeds after they fall from trees and cache them in groups of 1-10 between 5 and 30 mm deep in soil. They usually choose to cache seeds in mineral soil in the open or under thin layers of plant litter under shrubs.

Fig. 21. Yellow pine chipmunks are the most abundant and most effective dispersers of pine seeds in the Whittell Forest.

Most caches are within 50 m of the source tree, usually in the Jeffrey pine zone, mixed coniferous forest or montane shrub habitats. Chipmunks retrieve caches during the fall and eat the seeds and also add them to their winter larders (Kuhn and Vander Wall in prep.). Their winter larders often contain more than a thousand pine seeds, which must sustain them until spring. The relationship between yellow pine chipmunks and Jeffrey pine (and other large-seeded pines) is mutually beneficial: the chipmunks benefit by having a nutritious food supply during the fall and winter and the pines benefit because seeds that are not recovered (≈5-15% of those cached) germinate the following spring (Fig. 22). Over time, relationships such as these are often characterized by reciprocal evolutionary changes in the species involved, a process known as coevolution (Lanner 1996).

A similar mutualism exists between several of the dominant shrubs in the Whittell Forest and seed-caching rodents. These shrubs include antelope bitterbrush, Sierra bush chinquapin and greenleaf manzanita (Vander Wall 1994, 1995, Roth and Vander Wall 2005). As with the pines, yellow pine chipmunks and other rodents gather the seeds of these shrubs and cache them in soil; unretrieved seeds germinate in the spring. These mutualisms between seed-caching rodents and large-seeded plants appear to be the dominant plant-animal interaction driving community structure and functioning in the Whittell Forest. Data collected in many years of field studies suggest that >50% of the plant biomass in the Whittell Forest has arisen from animal caches (including caches made by jays and nutcrackers; see the section on *Birds*) (Vander Wall 1992, 1993, Thayer and Vander Wall 2005, Roth and Vander Wall 2005).

Coevolved mutualisms among plants and animals have important indirect consequences. The large, nutritious seeds of Jeffrey pine, sugar pine, whitebark pine and Sierra bush chinquapin have evolved, in large part, because of their mutualistic interactions with seed-caching animals. Large seeds are more attractive to animal foragers, which increases the probability that the seeds will be gathered and cached. Further, large seeds are more likely to produce seedlings that survive in semi-arid landscapes of the eastern Sierra Nevada. But these seeds also are food for many other animal species that do not serve as seed dispersers, including black bears, mule deer, quail, chickadees, nuthatches, towhees, insects and many others. The evolution of larger, more nutritious seeds also increases the population sizes of seed-eating rodents, which creates a larger prey base for predators such as hawks, owls, weasels, and bobcats.

Fig. 22. A cluster of three Jeffrey pine seedlings. Jeffrey pine seeds that are not recovered by chipmunks germinate in the spring. This mechanism is the primary way that Jeffrey pine seeds are dispersed and seedlings established.

Catastrophic fires eliminate these mammal communities and many of the plants on which mammals depend, and it can take many decades to reestablish them. Prescribed fire, on the other hand, may have only minor effects on these animal communities and may actually have beneficial effects on the process of seed dispersal by animals. A study of prescribed burns at Incline Village in the Tahoe Basin, in forests very similar to those in Little Valley, found that rodents can colonize burned areas quickly (within 1-2 years) after low to moderate-severity fires (Briggs 2003). Chipmunks and mice continued to cache seeds on burned sites and the young pine seedlings arising from buried seeds showed rapid and vigorous growth in the ashy substrate on the forest floor (Briggs 2003).

The situation in the lodgepole pine forest is very different. Lodgepole pine grows on heavier soils that retain more moisture during summer. Lodgepole pine seeds are much smaller than those of the animal-dispersed pines (e.g., ≈5% the size of Jeffrey pine seeds) (Johnson et al. 2003), largely because seedlings can get established in these mesic areas without the aid of seed-caching animals. Consequently, most rodents don't forage for lodgepole pine seeds and when they encounter them they are much more likely to eat them than to bury them intact in caches (Vander Wall 2003). Thus, lodgepole pine is dispersed by the wind, not animals. The species interactions in lodgepole pine forests are very different from those that occur in Jeffrey pine forests. Lodgepole pine cones are small, lightly armored with spines, and unprofitable for most rodents to open (Smith 1970). Douglas squirrels (*Tamiasciurus douglasi*), however, are specialists on lodgepole pine cones, which they cut from the tree branches in early fall and store, whole, in shallow pits in the ground. During the winter, they eat the seeds from these stored cones. Since the seeds in these cones rarely, if ever, germinate, and are not available to other animals, this interaction has few positive consequences for other members of the animal community. However, Douglas squirrels sometimes store the cones of Jeffrey pine, which can attract the attention of black bears that dismantle the cones and eat the seeds (Kuhn and Vander Wall submitted).

Since the acquisition of the Whittell Forest by the University of Nevada in 1959, three species of mammals appear to have become locally extinct. Beavers (*Castor canadensis*), which are not native to the eastern Sierra, were eliminated in the early 1990s because they interfered with stream flows. Several colonies of Belding's ground squirrels (*Spermophilus beldingi*) existed in the meadow, but they have not been seen since about 2001. Porcupines (*Erethizon dorsatum*) were fairly common in the valley until the 1980s. The exact cause of these population declines is unknown, but these latter two species appear to have gone extinct "naturally", probably because of the reduction of ecological disturbances (fire suppression and/or the elimination of grazing).

Several large predators occur in Little Valley, including black bear (*Ursus americanus*), mountain lion (*Felis concolor*), bobcat (*Lynx rufus*), and coyote *(Canis latrans*). Mule deer (*Odocoileus virginianus*) are fairly common. Northern flying squirrels (*Glaucomys sabrinus*) are rare in Little Valley, and pine martens (*Martes americana*) might be there but have not been sighted in recent years. Both species are of special interest to state and federal wildlife management agencies because of their small or dwindling populations, and both depend on old-growth forests. Prescribed fire would probably benefit these species by creating conditions more similar to those present before Euro-American settlement.

Appendix 2 is a list of mammal species found in the Whittell Forest.

Birds

The Whittell Forest supports a diverse montane bird community. The Great Basin Bird Observatory has identified montane riparian (willow and alder), meadow and aspen forest habitats as critically important habitats for birds in the Carson Range. There are about 39 ha (96 acres) of riparian habitat in Little Valley, most of it along Franktown Creek. In 1995, Alan Gubanich, Jim Eidel and more than 100 volunteers (over a 10 yr period) initiated a MAPS (Monitoring Avian Productivity and Survivorship) bird banding program in riparian habitat along Franktown Creek in Little Valley (Fig. 14). The purpose was to determine the population densities, survivorship, and health of willow riparian birds in Little Valley. They recorded 56 bird species in or adjacent to the kilometer long patch of riparian habitat (Fig. 23). Common willow riparian breeding birds include MacGillivray's warbler (*Oporornis tolmiei*), Wilson's warbler (*Wilsonia pusilla*), warbling vireo (*Vireo gilvus*), dark-eyed juncos (*Junco hyemalis*), song sparrows (*Melospiza melodia*), and Lincoln sparrows (*Melospiza lincolnii*). A number of species such as mountain chickadees (*Poecile gambeli*), American robin (*Turdus migratorius*), red-breasted nuthatch (*Sitta canadensis*), and Cassin's finch (*Carpodacus cassinii*) feed in

Fig. 23. A male western tanager (*Piranga ludoviciana*), one of many birds captured as part of the MAPS bird banding program in Little Valley.

the riparian areas but breed in adjacent coniferous forests. Dusky flycatchers (*Empidonax oberholseri*), fox sparrows (*Passerella iliaca*), and green-tailed towhees (*Pipilo chlorurus*) breed in nearby bitterbrush, tobacco brush and manzanita shrubs. Their study also revealed that willow riparian habitat in Little Valley is an important stopover point for spring and fall migrants and a molting area in late summer for birds like orange-crowned warblers (*Vermivora celata*).

The general consensus is that Little Valley riparian bird populations are healthy. The breeding success of riparian nesting birds in montane riparian habitat is a function of vegetation density. Ammon and Stacey (1997) found that breeding success was significantly greater in the northern end of Little Valley (i.e., the Whittell Forest) than in the more recently grazed southern end of the valley, apparently because the riparian habitat (principally willow) is denser north of the fence. However, the riparian habitat seems appropriate for several species of special interest, such as willow flycatcher (*Empidonax traillii,* Fig. 24), but these species are rarely encountered in Little Valley.

Fig. 24. Willow flycatcher. The willow habitat in Little Valley seems appropriate for this sensitive species, but it is rarely encountered. Improving willow habitat along Franktown Creek may encourage this species. Photograph by Heather Mathewson.

Riparian habitat is not very widespread in the Carson Range, it is being degraded along most streams in western Nevada, and it is considered critical for avian diversity and conservation. Consequently, it would be desirable if riparian habitat expanded in Little Valley. Currently, the expansion of riparian habitat along Franktown Creek appears to be constrained by encroaching young lodgepole pines. Removal of the young pines would likely increase riparian and meadow habitat. In any management plan, riparian habitat should be protected and developed. A high-severity wildfire would be catastrophic, at least over the short term.

Aspen is also a habitat of special interest for bird communities. Numerous bird species, such as northern goshawk (*Accipiter gentilis*) and blue grouse (*Dendragapus obscurus*), breed and forage in aspen forests (DeByle at al. 1987). Aspen groves are not very numerous or widespread in Little Valley, comprising only 5 ha (12.4 acres) (Fig. 8). Aspen has increased in acreage since the mid 1990s when beavers were extirpated from the valley.

The pine forests and mixed coniferous forest habitats in Little Valley are not considered critical habitats for birds simply because these forest types are so widespread in the Sierra Nevada. No species of bird in conifer forests appears to depend on only one tree species or forest type (Hutto 1995). Nevertheless, conifer forests in Little Valley support diverse bird communities. With regard to forest health, two of the most important birds are Clark's nutcracker (*Nucifraga columbiana*) and Steller's jay (*Cyanocitta stelleri*). That is because, like yellow pine chipmunks and several other species of forest rodents discussed in the section on mammals, these corvids gather and store pine seeds in the soil during the autumn. They eat most of the stored seeds during autumn, winter and spring, but they do not recover all the buried nuts. These caching activities constitute an important means of seed dispersal for several Sierra Nevada pines. Steller's jays are the most important avian dispersers of sugar pine (Thayer and Vander Wall 2005), Clark's nutcrackers are the most important dispersers of whitebark pine (Tomback 1978, 1982, Hutchins and Lanner 1982), and both species contribute to the dispersal of Jeffrey and ponderosa pines (Tomback 1978, Vander Wall unpubl. data). The roles of these birds is different from that of the rodents that disperse pine seeds, because corvids can disperse pine seeds much farther and are likely responsible for colonization of new suitable habitats. However, they also cache within these pine forests, and contribute to the overstocking of the forest understory with pine saplings.

Thinning (selective removal of certain trees to reduce competition) often has important effects on yellow pine forest bird communities (Finch et al. 1997). The more open canopy created by thinning allows more light penetration to the forest floor, leading to an increase in shrubs and herbaceous plants and an increase in arthropod diversity and abundance. These changes provide more cover and resources for birds that forage in the forest understory (Siegel and DeSante 2003). Low to moderate-severity prescribed fire can have a similar effect on vegetation and on bird communities (Lyons et al. 1978, Bock and Bock 1983, Lyons and Marzluff 1985, Finch et al. 1997, Saab et al. 2004). Loss of snags (standing dead trees that provide nest sites, roosts, and food resources for some birds) from cutting or prescribed fire is not likely to be a problem because snags are common in Little Valley and prescribed fire is likely to create some new dead trees (Horton and Mannan 1988, Morrison and Raphael 1993). Hutto (1995) has argued that even high severity fire is beneficial to many conifer forest bird populations in the Rocky Mountains. He suggests that many bird species have adapted to the resources created by periodic fire. Resources may include the insects that usually infest fire-killed or weakened trees, or other foods or nest sites that are available in early seral plant communities of the post-fire environment. One of the best examples is the black-backed woodpecker (*Picoides arcticus*), a relatively rare bird that became temporarily common following the 1981 fire on the east slope of the Whittell Forest. Birds that inhabit early successional plant communities are often dependent on fire for their long-term persistence. In fact, Hutto (1995) stated that "the conservation of biological diversity is likely to be accomplished only through the conservation of fire as a process" in Rocky Mountain conifer forests. The extent to which this is also true of the Sierra Nevada, with its low to moderate-severity fire regime, is uncertain.

Several bird species of special interest (because of small or dwindling populations) occur or potentially occur in the Whittell Forest, including northern goshawk (*Accipiter gentilis*), flammulated owl (*Otus flammeolus*), willow flycatcher, and mountain bluebird (*Siala currucoides*). The fuel-reduction plan described here is not expected to have any negative consequences for these species, and may benefit some of them.

A list of birds known to have occurred in the Whittell Forest is presented in Appendix 3.

Reptiles and Amphibians

Amphibians and reptiles are not well represented in Little Valley. The dry summers do not favor amphibians, and the cold winters do not favor reptiles. Western toads (*Bufo boreas*) occur along the riparian zone, and Pacific tree frogs (*Hyla regilla*) occur in the bitterbrush shrublands and in lodgepole forests, usually within several hundred meters of a stream. Mountain yellow-legged frogs (*Rana muscosa*) have not been reported in the area. The only lizards in Little Valley are western fence lizards (*Sceloporus occidentalis*), which are uncommon and usually small. The only snakes in Little Valley are the rubber boa (*Charina bottae*), common garter snake (*Thamnophis sirtalis*), and western terrestrial garter snake (*Thamnophis elegans*).

Prescribed fire and other forest treatments are not expected to have any deleterious or beneficial effects of reptiles and amphibians. High-severity wildfires, on the other hand, would be detrimental.

Aquatic Ecosystems of Little Valley

There is growing concern over the quality and functioning of freshwater ecosystems (Naiman et al. 1995, Firth 1998, Naiman and Turner 2000, De Meester and Declerck 2005). Key indicators of the decline of freshwater systems include a significant decrease in biodiversity, an increasing rate of human consumption, and degradation in the quality of water. Reserves or natural areas such as the Whittell Forest and Wildlife Area can play a significant role in helping to protect and preserve freshwater systems and to provide model systems for scientific inquiry that can create information to better manage natural resources. The decline in the functioning of freshwater systems is an ongoing issue in the Sierra Nevada and its spur ranges such as the Carson Range. For example, Moyle and Randall (1997) found that the aquatic biota of most watersheds (58%) in the Sierra Nevada is in “poor to fair” condition based on an index of biotic integrity. Management actions, such as prescribed burning in Little Valley, need to consider the potential impacts of those activities on aquatic resources.

The primary aquatic resource of Little Valley is Franktown Creek (Fig. 25). Franktown Creek is a key tributary for Washoe Lake and an important source of irrigation water for pasture lands in Washoe Valley. A number of small streams, springs, and seeps feed into Franktown Creek. The source of most of this water is runoff that comes from the higher slopes on the west side of the valley. This high ridge (≈2600-2800 m) and east-facing slopes receive very heavy winter snows, which can take until mid summer to melt, resulting in numerous, small, perennial tributaries. The much lower ridge on the east side of Little Valley (≈2050-2150 m) receives much less snow that usually melts during April. The more open forest and west-facing slope on the eastern side of the valley result in higher evaporation rates and intermittent streams that usually flow for only a few days immediately after spring snowmelt. The result is that the terrain to the west of Franktown Creek is relatively moist with wet meadows and seeps that feed into Franktown Creek, whereas the terrain to the east of Franktown Creek is much drier and contributes little directly to Franktown Creek (Fig. 8).

Montane wet meadows occur in the southwestern portion of the Whittell Forest (Fig. 16). Wet meadows often have poorly drained soils. They tend to be drier than marshes and are highly dependent upon snowmelt for moisture. Wet meadows and seeps are valuable resources for biodiversity and ecosystem functioning. For example, the US Environmental Protection Agency lists the values of wet meadows as (1) reducing the severity of seasonal flooding by collecting runoff, (2) removing excess nutrients from water, (3) providing a high diversity of grasses, sedges, and wildflowers, and (4) providing valuable food resources for wildlife. They can also serve as effective fire breaks.

Fig. 25. The south fork of Franktown Creek during summer.

There are well-developed riparian zones and floodplains along Franktown Creek, especially in the northern portions of Little Valley where there were beaver dams in the recent past (Ellsworth pers. obs.). Beavers no longer occur in Little Valley. The riparian habitat along the stream channel should be considered a critical aquatic resource. Riparian systems are important in maintaining regional biodiversity and are considered essential habitats and corridors for many species (Naiman et al.1993). Riparian systems are also critical resources that provide important ecosystem functions such as the removal of suspended sediment and nutrients during flood events (Tabacchi et al. 1998, Wissmar 2004). Intact riparian corridors have the potential to serve as valuable buffers against disturbances, such as reducing the effect of fires and floods on water quality.

Common human-induced disturbances in riparian systems include fire suppression, livestock grazing, flow regulation, water diversions, channel modifications and the introduction of exotic species (Dwire and Kauffman 2003).

In Little Valley, aquatic ecosystems appear to be healthy based on observations of water clarity and the high density of caddisfly larvae (Ellsworth pers. obs.) (Fig. 26). Caddis flies have long been considered to be important indicators of water quality and are often used as biological indicators of ecosystem functioning. Studies in nearby Sagehen Creek basin in the northern Sierra Nevada indicate that there is a high degree of diversity and density of caddis flies in wet meadow seeps (Erman and Erman 1990,1995). In the Sierra Nevada and throughout the western US these systems face threats from livestock grazing (Dobkin et al. 1998) and the encroachment of conifers (Norman and Taylor 2005).

Over the past several decades, there has been extensive research on the short-term and long-term effects of fire on streams and watersheds. This is, in large part, because of the environmental problems associated with the increase in the frequency of intense fires and interest in the effects of the Yellowstone National Park fires of 1988. Also there has been a shift in thinking among ecologists, many of whom now accept that natural systems are not in equilibrium conditions: disturbance and patch dynamics play important roles (White and Pickett 1985) and streams are no exception (Power et al. 1988, Dunham et al. 2003, Minshall 2003). Disturbances, such as fire, may be beneficial

Fig. 26. Caddis fly larvae in a seep leading to Franktown Creek in Little Valley.

in the long-term because they often increase physical and biological diversity (Benda et al. 2003). Although many studies have investigated the effects of fire on streams, a large number of basic questions remain unanswered and the response of systems appears to be highly variable (Bisson et al. 2003, Dunham 2003). The response of macroinvertebrate communities (which are often used as indicators of ecosystem health and functioning) to fire is individualistic, varying among systems and largely depending upon stochastic factors (Minshall 2003). This variability creates a situation in which it is very difficult to make informed management decisions in regards to the interplay between fire and aquatic systems.

The effect of fire on streams can be either direct or indirect. Direct effects are short-term influences of the fire on the biological and physical properties of the system. Indirect effects occur over longer periods of time and include inputs of organic and inorganic debris, stream channel reorganization, and the revegetation of watersheds (Minshall et al. 1997, Dunham et al. 2003). Based on studies of stream macroinvertebrates, indirect effects are often greater than direct ones (Minshall 2003). Generally, the largest impacts are the physical changes associated with flooding and the associated mass movement and channel alteration. However, Robinson et al. (2005) state that long-term studies indicate that the majority of channel changes occur within 10 years after a fire. This supports the idea that healthy streams are resilient to intense natural disturbances. Post-fire streams tend to become more eutrophic as a result of the increase in solar radiation and increase in nutrients (Gresswell 1999, Robinson et al. 2005). Fire tends to have more severe ecological effects in systems that have a recent history of human disturbance and resource extraction, such as logging, road building, mining, and grazing (Minshall 2003). The Franktown Creek watershed has a history of human disturbance, especially logging and grazing (see History of Little Valley), but these activities have declined significantly since the 1960s. Headwater portions of watersheds tend to be more affected by fire than larger streams of lower reaches (Minshall 2003). The consensus appears to be that streams are resilient systems that recover quickly from fire, even when they occur in areas such as Little Valley where there have been extended periods of fire suppression (Minshall et al. 2001, Dunham et al. 2003, Minshall 2003, Robinson et al. 2005).

Even though evidence indicates that naturally functioning streams are resistant and resilient to fire, a high-intensity fire could have numerous negative effects on Franktown Creek, especially downstream of the Whittell Forest and Wildlife Area. A potential consequence of a high-intensity fire in the Franktown Creek basin is nutrient loading from the runoff of organic debris and ash, which could lead to eutrophication of downstream portions of the basin and Washoe Lake. Spencer et al. (2003) state that this is a concern that is often overlooked in natural resources management. The lower portion of Franktown Creek (downstream from UNR property) is listed on Nevada's 2004 303(d) impaired waters list. The stressor in this case is low dissolved oxygen and the area of concern is upstream from Washoe Lake through irrigated pasture.

Management strategies should give special consideration to wet meadows and seeps as they are important for maintaining water quality and biological diversity. They are also important in the functioning of nearby streams. For example, Micheli and Kirchner (2002) calculated that banks without wet meadow vegetation in the southern Sierra Nevada are roughly ten times more susceptible to erosion than banks with wet meadow vegetation.

A potential threat to the viability of the meadows is the extensive encroachment of lodgepole pines, which has the potential to significantly alter the wet meadow ecosystem. The expansion of pine forests along forest-meadow ecotones is common in the western United States and can occur if grazing is discontinued and fires are suppressed (Jakubos and Romme 1993, Norman and Taylor 2005). Considering the potential for rapid dispersal and growth of lodgepole pines, this is of immediate concern for the management of Little Valley.

Sections of Franktown Creek have experienced incision and stream bank erosion that should be monitored and considered in management alternatives. If this continues, the erosion may have significant negative impacts on downstream environments. Flow dynamics and vegetation type both play an important role in controlling stream bank stability and incision (Simon and Collison 2002). Incision may be a result of past disturbances in the watershed, especially in the intensely logged and grazed headwaters of Franktown Creek. Possible management strategies include stream bank stabilization with riparian vegetation and the introduction of measures to increase the complexity of flow so that pools develop to buffer flood events.

PART 2 Management Plan

Introduction

The structure of forest communities in the Carson Range (and throughout the mountains of the western United States) has changed dramatically since the time of Euro-American settlement. Before we can develop an effective management plan for the Whittell Forest and Wildlife Area, it is necessary to understand and appreciate the conditions that existed during the period before Euro-American settlement (hereafter presettlement). This includes forest structure and composition and the nature of key disturbance processes (e.g., the fire regime) that helped to create and maintain those forests. One goal of our management plan for the Whittell Forest should be to approximate, to the extent possible, the structure and functioning of the indigenous, presettlement ecosystem (i.e., return within the range of natural variation; Morgan et al. 1994, Landres et al. 1999). This, of course, will not be possible to achieve in one treatment cycle, but will require repeated treatments over many decades (Allen et al. 2002). To do this effectively, we need to better understand what conditions existed during the presettlement period (i.e., the reference conditions; Moore et al. 1999, Swetnam et al. 1999, Taylor 2004) and how fire and other processes helped to shape those conditions. Knowledge of the reference conditions will help us identify restoration goals and develop restoration treatments. Further, management of the University's Whittell Forest and Wildlife area represents an opportunity to communicate to students, our neighbors, and the public the nature and causes of ecosystem change over the past 130 years and the long-term advantages of returning to an ecosystem that resembles presettlement conditions.

We begin Part 2 of the management plan by describing the fire regimes and forest structure that existed before the forests of the Carson Range were clear-cut and fire suppression imposed in the late 19th century. This section clarifies the potential role of prescribed fire in managing the Whittell Forest in a naturalistic way. Second, we discuss the merits and shortcomings of alternative treatment options. Third, we provide a rationale for what areas and habitats should be treated first within the Whittell Forest and describe the role of these treated areas in a regional strategy to reduce the risk of wildfire to forest and property in this portion of the Carson Range. Fourth, we describe the future forest conditions that we hope to attain. Fifth, we present a detailed description of the locations, acreages, arrangement, and characteristics of 46 potential treatment units along with a brief description of the treatments to be conducted at each unit and the relative priority of those proposed treatments. Sixth, we voice some of our concerns about environmental impacts of our treatments and how we might mitigate potential adverse effects on the Whittell Forest during our management activities. Finally, we describe the role of the 'fire prescription' and permits that must be obtained before we prepare units for treatment.

Presettlement Fire Regimes and Forest Structure

When a tree experiences a fire, a record of the event can be recorded as a fire scar in the wood at the base of the tree. Scientists use dendrochronology (the analysis of patterns of tree-ring growth) to date a particular fire or sequence of fires by examining the incidence of fire scars and counting the growth rings backward from the present year or other reference date. Even stumps of trees cut immediately after settlement of the area can contain valuable fire records. The eastern Sierra Nevada is an especially favorable environment to preserve this type of information because the dry climate results in very slow decomposition rates. Fire scar dendrochronology can produce a highly accurate fire history of a stand of trees or watershed. Several very thorough fire histories are now available for coniferous forests of the Sierra Nevada.

Stephens and Collins (2004) conducted one such study in the Blodgett Forest Research Station, ≈70 km west of Little Valley on the west slope of the Sierra Nevada. In a ponderosa pine, sugar pine, and incense cedar forest, Stephens and Collins determined the fire history of 73 trees at six sites. Fires were recorded from 1649-1921. They found a median point fire return interval ('point' refers to the fire history of an individual tree) of 9-15 yr and a median composite fire return interval ('composite' refers to the combined fire histories of the sampled trees at a site, in this case 22-37 acres (9-15 ha)) of 5-10 yr. Point samples are more conservative estimates of fire occurrence, and composite samples provide a more comprehensive record of local fire history (Stephens and Collins 2004). This study indicates that fire was a common occurrence in pine forests of the central Sierra Nevada until ≈1900, when there was a sudden and dramatic decline in fire frequency.

At Valentine Nature Reserve, ≈190 km southeast of Little Valley, Stephens (2001) found that between 1745 and 1889 the median composite fire return interval was 9 yr (range 4-17 yr) in a Jeffrey pine forest. A nearby mixed coniferous forest dominated by red fir (a mid-elevation coniferous forest) had a median fire return interval of 24 yr (range 13-38 yr). Neither forest has experienced a fire since 1889 (Stephens 2001). Further south in the Sierra Nevada, in Sequoia National Park, Caprio and Swetnam (1995) sampled the fire scars of 91 trees at 12 ponderosa pine sites along an elevational gradient and found that mean composite fire return intervals between 1700 and 1900 ranged from 4.6-10.7 yr (range 1-36 yr).

At the northern edge of the Sierra Nevada, near Lassen Volcanic National Park, ≈190 km northwest of Little Valley, Taylor (2000) reported a median point fire return interval of 16 yr and median composite fire return interval of 4-6 yr in Jeffrey pine forests for the period 1656-1849. Taylor (2000) reported a dramatic decrease in the occurrence of fire following 1905. A few kilometers to the east, in the Caribou Wilderness Area, Taylor and Solem (2001) found median fire return intervals of 70 yr in white fir-Jeffrey pine forests, 67 yr in lodgepole pine forests, and 41 yr in red fir-white fir forests between 1735-1874. These fire return intervals are longer than those found elsewhere in the northern Sierra Nevada and southern Cascades and may reflect an incomplete fire history of the area.

One of the most relevant fire chronologies for the Whittell Forest is that established by Taylor and Beaty (2005) on the east shore of Lake Tahoe. Taylor and Beaty (2005) sampled fire scars on 93 nineteenth century Jeffrey pine stumps (Fig. 27) or recently dead trees in 8 watersheds from just west of Marlette Lake to Zephyr Cove. They recorded 121 fires between 1650 and 1850. Median composite fire return intervals within watersheds ranged from 3-9 yr (full range 1-36 yr). Fire occurred somewhere within the 8 watersheds on an average of once every 1.5 yr. However, no fires were

Fig. 27. Many of the stumps from trees cut in the 1870s are still incredibly well preserved, like this one on the slopes above Little Valley, and some contain fire scars that can be used to reconstruct past fire histories.

detected in this portion of the Carson Range after 1871 (a period of 134 years). A few kilometers to the south, Taylor (2004) sampled nineteenth century stumps and contemporary trees on 20 plots south of Spooner Summit and found a median fire return interval in Jeffrey pine forests of 9 yr between 1450 and 1850. The mean fire return interval in red fir-western white pine forests was much longer (76 yr), but similar to red fir forests elsewhere in the Sierra Nevada (65 yr, Pitcher 1987; 70 yr, Taylor 2000). Generally, fire return intervals increased with increasing elevation (Caprio and Swetnam 1995, Taylor 2004). Few data exist on fire return intervals in lodgepole pine forests in the northern Sierra Nevada, but they appear to be intermediate between those of Jeffrey pine-white fir and red fir-western white pine forests (Caprio 2005). Again, no fires occurred after 1871.

Although more distant, the fire history of Sierra San Pedro Martir, Mexico, is of particular interest because this plant community is ecologically very similar to the presettlement Jeffrey pine forest of Little Valley (Minnich et al. 1995, Stephens and Gill 2005). The Sierra San Pedro Martir forest is a Jeffrey pine-white fir association with some sugar pine, lodgepole pine, aspen, and incense cedar. It contains an understory of green-leaf manzanita and a species of *Ceanothus* related to tobaccobrush on decomposing granitic soils. Of particular interest, forests in this isolated region of northern Baja California have never been logged and have not experienced systematic fire suppression (Minnich et al. 2000, Stephens et al. 2003). Consequently, this forest represents the best extant example of the likely state of the Whittell Forest before it was logged and experienced more than a century of fire suppression. Stephens et al. (2003) recorded median point fire return intervals of 22.5 yr (range 12.4-54.7 yr) and median composite fire return intervals of 5-13 yrs (range 1-43 yr) and concluded that fire frequencies at Sierra San Pedro Martir were similar to those in Jeffrey pine forests in the eastern Sierra Nevada before European settlement. However, despite lack of systematic fire suppression, the frequency of wildfires has decreased in this region of northern Mexico since 1946 (Minnich et al. 2000). The causes of this change in fire frequency are uncertain, but probably include increased cattle grazing (and concomitant reduction in fine fuels that help carry a fire), cultural disruption of native populations, and climate change (Stephens et al. 2003).

Position within an annual growth ring at which a fire scar occurs provides information on the season of fire occurrence. In the Tahoe Basin and southern Sierra Nevada, over 90% of historic fires occurred in 'latewood', during the dormant season (Caprio and Swetnam 1995, Stephens and Collins 2004, Wright and Agee 2004, Taylor and Beaty 2005). This is interpreted as late summer or early fall. Presettlement fires during the late summer and fall occurred at the same season as the contemporary peak thunderstorm activity and dry fuels in the Sierra Nevada, conditions that would favor ignition of fires (Caprio and Swetnam 1995, Taylor 2004).

In the Sierra Nevada, occurrence of widespread fires is significantly correlated with dry years (low winter-spring precipitation), and fires often occur 1-3 yr after wetter than average winter-spring weather (Swetnam 1993, Norman and Taylor 2003, Grissino-Mayer et al. 2004, Stephens and Collins 2004, Wright and Agee 2004, Taylor and Beaty 2005). The wet years contribute to the buildup of fine fuels (e.g., grasses, forbs) and the dry years create the conditions for ignition of those fuels. At the regional scale, these fires are strongly correlated with the Pacific Decadal Oscillation (interdecadal variation in north Pacific sea surface temperatures), which appears to exert control over fuel and vegetation dynamics (Norman and Taylor 2003, Taylor and Beaty 2005). Analyses of the composite fire history of an area also suggests that fuel accumulation between fires is important. For example, Swetnam (1993) found an inverse relationship between the frequency of fires and the aerial extent and intensity of those fires. Longer intervals between fires were associated with larger, more severe fires.

Frequent fires would have consumed most plant litter and coarse woody debris, resulting in forests with scant fuels. These fires were typically low-intensity surface fires of low severity (Covington and Moore 1994, Wright and Agee 2004, Taylor and Beaty 2005). Despite the disturbance, most mature woody plants were not greatly affected because they had evolved with frequent natural fire. Mature trees were seldom killed by fire because of their thick, fire-resistant bark. Most shrub species (e.g., greenleaf manzanita, tobaccobrush, Sierra bush chinquapin) have the ability to resprout after fire. The disparity between the point and composite estimates of fire return intervals indicates that many fires in the presettlement period were either of very small aerial extent, affecting perhaps a single tree or cluster of trees, or were larger but very patchy. The amount, type, and spatial arrangement of fuel and topography influence the way a fire spreads. In some cases, the amount of fuel available was insufficient to carry a fire, even though ignition occurred. Frequent small and/or patchy fires had a 'fine-grained' effect on vegetation and contributed to heterogeneity in forest structure (Swetnam 1993, Minnich et al. 2000). However, the fire scar record also indicates that some less frequent fires were widespread, affecting large regions. These fires were probably more intense (more heat released) and more severe (had greater effects on vegetation), perhaps increasing homogeneity in forest structure (Swetnam 1993).

Presettlement plant communities were dominated by fewer and larger trees compared to contemporary forests, not unlike the forests at Sierra San Pedro Martir, Mexico (Minnich et al. 2000, Stephens et al. 2003). In Jeffrey pine-white fir forests, mature trees were widely spaced. Historical records show that some presettlement trees in the Tahoe Basin were 6-8 ft (2-2.5 m) in diameter (Lindstrom 2000). Many of these trees were in excess of 250 yr old. Taylor (2004) estimated average presettlement tree density in old-growth Jeffrey pine-white fir forest and mixed-coniferous forest to be 25 trees/acre and 27 trees/acre (63 trees/ha and 67 trees/ha), respectively. Mean basal area was estimated at 111 ft^2/acre (25.3 m^2/ha) (based on nineteenth century stumps) and 118 ft^2/acre (27.0 m^2/ha) (based on old growth trees). Taylor (2004) estimated mean tree density in old-growth red fir forests to be 43 trees/acre (107 trees/ha) (based on old-growth trees) and 65 trees/acre (161 trees/ha) (based on stumps), but the two estimates for basal area were similar (≈240 ft^2/acre or ≈55 m^2/ha). For the understory, periodic fire probably increased plant species richness, especially of annual and biennial forbs (Laughlin et al. 2004). Regeneration of new trees was apparently rare (Taylor 2004). Numerous pine seedlings would accumulate between fires, but most were killed during fires, resulting in relatively few saplings and pole-sized trees. For example, Mast et al. (1999) found recruitment rates of only 0.4-3.6 adult ponderosa pine trees/ha/decade. A similar pattern has been observed at Sierra San Pedro Martir (Minnich et al. 2000).

Contemporary forests in the Carson Range developed after old-growth forests were almost completely clear-cut between 1861 and 1890 (Taylor 2004, Lindstrom 2000) and during an era of fire suppression that became federal policy in the 1890s (Agee and Skinner 2005, Stephens and Ruth 2005). Much of the semi-arid West experienced a similar history (Parsons and DeBenedetti 1979, Bekker and Taylor 2001, Grissino-Mayer et al. 2004, Wright and Agee 2004). During this period, forests changed dramatically (Taylor 2004, Taylor and Beaty 2005). Our current forests have smaller, more numerous trees. In the decades following logging and fire exclusion (1875 to 1915), precipitation was greater than normal in the Lake Tahoe watershed (Lindstrom 2000). Approximately 25 years after fire suppression began, Leiberg (1902) noted a pronounced increase in the number of pine sapling in northern Sierra Nevada pine forests. Jeffrey pine density east of Lake Tahoe, for example, is about five times greater and basal area is two times greater than in persettlement forests (Taylor 2004). Densities of small trees have increased markedly as forests have been transformed from an old-growth age structure to predominantly young growth. Tree recruitment (seedlings and saplings) has increased, unchecked by periodic fire. In open Jeffrey pine forests in Little Valley, for example, there were ≈9,200 Jeffrey pine seedlings/acre (≈23,000 seedlings/ha) and ≈200 Jeffrey pine saplings/acre (≈500 sapling/ha) in fall 2004 (Vander Wall unpublished data). As they mature, these young trees can form dense thickets and will likely add to the continued overcrowding of Jeffrey pine forests in the future. Tree species composition has shifted from more fire-resistant pines to less fire-resistant white fir and incense cedar (Parsons and DeBenedetti 1979, Minnich et al. 1995, Fule and Covington 1999, Taylor 2000). Shrub cover has also probably increased. These forests are more uniform and less structurally variable. More importantly, fuel loads in the form of needles, cones and coarse woody debris are much greater and more continuous than in presettlement forests. In some places, deposits of plant litter are more than 1 ft deep. Moderately high annual primary production, low rates of decomposition and lack of fire have created these abnormally high fuel loads. The lack of fire has disrupted nutrient cycling (Parsons and DeBenedetti 1979, Johnson et al. 1998, 2004). In recent years, the accumulation of heavy fuel loads has been exacerbated by pine bark beetles that have killed many trees during droughts in 1986-1994 and 2000-2004. The close spacing of trees and heavy fuel loads have created conditions that favor the all-too-familiar high intensity, high severity, stand-replacing crown fires, which can have detrimental effects on soils, watersheds and wildlife habitat.

The frequency and spatial scale of disturbances caused by presettlement fires had important consequences for animal communities. The presettlement fire regime with its relatively small, cool fires provided animals with a chance to escape or to avoid the fire by emigrating to a nearby unaffected area. Arboreal animals could retreat to the safety of the treetops. Recolonization of a burned area by many species of animals and birds after low-intensity fires is often rapid (Emlen 1970, Briggs 2003). Such is not the case with the often catastrophic postsettlement fire. Only the most mobile animals (e.g., birds, mule deer, black bears) can avoid being consumed in a fire. Colonization of a severely burned forest by less vagile animals can take many years. The development of the animal community is linked to succession of the plant community, which can take decades.

The available evidence indicates that frequent, low- to moderate-severity fire is a key process shaping the structure and functioning of semi-arid forests in the Sierra Nevada. Suppression of fire has led to a steady decline in ecosystem health (e.g., reduced resistance to catastrophic fire, loss of species diversity, disrupted nutrient cycling). According to Arno and Fiedler (2005), the task of forest managers throughout the West is to carefully and gradually reintroduce fire into fire-dependent forest landscapes. Knowledge of presettlement conditions (i.e., reference conditions) helps to clarify the causes and extent of forest change, but it is not possible to return forest ecosystems to presettlement conditions (Moore et al. 1999, Allen et al. 2002, Brown et al. 2004). Changes in climate and land-use patterns make that impossible. In the case of the Whittell Forest, improved ecosystem health could be achieved by using prescribed fire and other treatments in selected portions of the forest to create conditions more similar to the historic, natural range of variation in forest structure. This policy has the added benefit of reducing the risk that a large, intense, catastrophic wildfire will occur and negatively affect biological communities and private property.

Alternative Options for Reducing Fuels

Prescribed fire is only one of several possible ways of reducing fuels in the Whittell Forest. What about the alternatives?

Firewood cutting – Some have suggested that our fuel problems could be diminished by opening our land to the general public and allowing people to remove firewood. This option has many shortcomings and few advantages. First, the University might be held liable by someone who was injured while cutting wood in the Whittell

Forest, or someone who lost control of their vehicle while hauling a heavy load of firewood down our steep access road. Second, many visitors would probably drive off-road to facilitate cutting and loading firewood, causing environmental damage, potentially interfering with established research sites, and diminishing the value of the Whittell Forest as an outdoor laboratory for teaching. Third, the Whittell Board would have to hire someone to supervise wood-gathering activities. Fourth, opening our land to the public could increase public interest in the Whittell Forest, potentially having the long-term effect of increased recreational activity in the Whittell Forest, which is contrary to our primary objective of maintaining Little Valley as a primitive area. And fifth, most of the fuel we need to eliminate is not suitable as firewood because it is partially decomposed or too small in diameter. However, it may be feasible to engage the UNR Forestry Club or commercial firewood cutters to remove some wood if they would agree to keep all vehicles on roads. This option would probably reduce the amount of dead fuel by less than 20% and would not alleviate the need for prescribed fire.

Chipping and hauling – Fuels (e.g., logs, dead branches, small live trees) could be cut, chipped and hauled away. The two main disadvantages of doing this are expense and environmental damage. Removing thousands of tons of wood chips would require heavy equipment to chip the fuel and haul it away. To be effective, this heavy equipment would have to leave the road and move through the forest to access fuels, causing extensive disturbance to the landscape. This method could be very expensive, probably costing thousands of dollars per acre. Spreading the chips on site would be cheaper but would not really achieve the goal of eliminating the fuel, and would still involve significant mechanical disturbance.

Logging – The University could open the Whittell Forest to commercial logging. Removal of small- and medium-diameter trees from crowded stands could be beneficial by thinning the forest and reducing the probability of future pine bark beetle infestation. However, ground-based logging requires the use of heavy equipment off road to collect logs and move them to yarding areas. This extensive disturbance violates the Regents' mandate that the Whittell Forest be maintained as a primitive area. Further, removing healthy trees adds to the accumulation of downed, woody debris in the forest, because the limbs and tops of trees are left in the forest. Brown et al. (2004) state that "thinning is unlikely to meet all ecological objectives unless it is combined with prescribed fire." In other words, logging should not be viewed as a substitute for prescribed fire, but if logging (or non-commercial thinning) occurs, it should be followed by pile or broadcast burning. One option is to combine helicopter logging, which has less impact on the landscape, with burning of unharvested debris. The feasibility and economics of this option need to be investigated.

Grazing – Some have suggested that we reinstitute grazing by cattle and/or sheep to reduce some of the small fuels (grasses, shrubs and tree seedlings). This option violates the Regents' mandate to maintain the Whittell Forest as a primitive area, would interfere with the primary objective of facilitating teaching and research, and would be very damaging to much of the ecosystem (e.g., animals would trample vegetation, and reduce water quality) while providing only minimal benefits regarding fuel reduction. It should also be noted that the Whittell Board terminated grazing on University land in the mid 1960s because of the severe environmental damage that grazing had caused over the preceding decades (see History of Little Valley).

No action – The University could take no action and depend on decomposition to eliminate fuels. However, in the semi-arid Carson Range, fuels accumulate faster than they decompose. Our fuel problems will only become worse in the future. When the next severe drought occurs, the Whittell Forest is likely to experience another outbreak of pine bark beetles and another wave of tree mortality. The two most likely effects of taking no management action are an increased probability of a high-intensity wildfire and a loss of landscape- and species-level diversity if conifers continue to encroach into habitats where they historically did not occur, including the ecologically valuable meadow. If no action is taken, wildfire will eventually consume the fuels under conditions that might be very damaging to the Whittell Forest and neighboring lands, and would certainly threaten the safety of people and diminish the value of property. Action is needed to prevent a conflagration such as the Martis Valley fire or Waterfall fire.

Based on these considerations, the most effective methods for reducing fuel loads and increasing forest health in the Whittell Forest, *given the mandate to maintain the forest as a primitive area*, are: (1) mechanical hand thinning of small to medium diameter trees (i.e., <45 cm in diameter) and saplings where the forest is too dense, (2) removal of as much wood as possible in the form of firewood and as logs to construct a fence along the south boundary of the property, and (3) prescribed burning, including pile and/or broadcast burning depending on the situation, of the unharvested debris. Helicopter logging may be incorporated into future plans if deemed economically feasible.

Priorities for Treatment

Three principles helped us (Stephen Vander Wall and John Christopherson of NDF) determine which areas should be considered high priorities for treatment in this management plan. First, we only selected areas that could be treated safely and on which prescribed fire could be contained. Consequently, steep, roadless terrain that is very difficult or impossible for fire fighting equipment to access will not be treated. The excluded areas of the Whittell Forest include the steep, roadless coniferous forests on the west and northwest portion of the property and the mixed montane shrub and pine forests on the southeast portion of the property (Fig. 8). Second, those habitats in most need of treatment are those that have been most affected by the exclusion of fire following settlement in the 1870s (Taylor 2004). Taylor (2004) found that Jeffrey pine forests have changed more than higher elevation forests (e.g., red fir forests) and suggested that Jeffrey pine forests should have higher priority in management. Some mid-elevation Jeffrey pine forests have missed more than 13 fire cycles (i.e., 130 years without fire where the presettlement fire return interval was less than 10 yr), whereas high elevation red fir forests that had fire return intervals of 50-70 yr have missed only 2-3 fire cycles. Numerous missed fire cycles in the meadow habitat have also had a profound effect in that area. Third, treatment areas should form a continuous zone that can play a meaningful role in future suppression of a regional fire. It is pointless to treat a collection of disjunct sites that have no strategic relationship to one another. Treatment of each unit should be designed to improve the health of that unit, but it is important for any treatment also to play a part in a larger regional strategy for suppressing wildfire.

There are three habitat-regions in Little Valley that have conditions consistent with these guiding principles and that are in urgent need of treatment. The first is Jeffrey pine-white fir forests on the lower slopes of Little Valley. These forests have been most strongly affected by over a century of fire suppression (Taylor 2004). This is an extensive habitat, but we propose to only treat sites within ≈150 m of a road where fire-fighting crews and equipment can work. About 200 acres of this habitat have heavy fuel loads and dense stands of trees. Second, we selected areas in which young lodgepole pines are growing on the meadow. Prior to 1870, the meadow was kept treeless by periodic fire. After fire suppression began, the meadow was kept free of young lodgepole pines by foraging sheep and cattle (Fig. 28). But after grazing was suspended in ≈1965, numerous lodgepole pine seedlings appeared in the western and northern portions of the meadow. Today, ≈60 acres of the meadow has been converted to lodgepole pine forest (Fig. 29). This is significant because the treeless meadow was a natural firebreak. Over the past ≈40 years, the meadow has been diminished and fragmented by invading lodgepole pines. At the latitude of the first bridge, for example, young lodgepole pines have nearly eliminated meadow habitat, creating a 'bridge' for

Fig. 28. Aerial photograph of the meadow in Little Valley in early spring circa 1970. The southern Whittell Forest property line is at the bottom of the photograph and the campground is in the upper left corner. Franktown Creek runs northward on the west (left) side of the meadow. Note the nearly total lack of lodgepole pines and willows on the meadow.

Fig. 29. Young lodgepole pines have invaded the meadow habitat beginning in the mid 1960s. Today they threaten to cause the loss of habitat diversity and increase the risk of wildfire.

fires moving in a west-to-east direction to cross the valley bottom. We will gradually reestablish the continuity and size of the meadow by removing trees and burning the slash. Our third priority for treatment is several relatively open stands of mature lodgepole pine in the valley bottom. Lodgepole pine forest, which on the east side of the meadow lies between the meadow and Jeffrey pine forest, is a more flammable habitat than Jeffrey pine forest because the forest is much more crowded and lodgepole pine wood produces more heat when burned. Most of this habitat will not be treated, at least not in the early phases of this management plan. A small area of open lodgepole pine habitat will be treated in a manner similar to that of Jeffrey pine forest, after the adjacent meadow and Jeffrey pine forest have been treated.

These three habitats, along with the dry meadow, form a relatively wide zone that runs south-to-north through Little Valley (Fig. 30). This zone includes ≈270 acres of Jeffrey pine forest, ≈125 acres of lodgepole pine forest, ≈90 acres of dry meadow, ≈25 acres of willow riparian, and 10 acres of *Wyethia* meadow, for a total of 520 acres. Only ≈360 acres are in need of treatment, including about 75% of the Jeffrey pine forest and the areas where lodgepole pine has invaded the meadow.

The general goals will be to thin the Jeffrey pine forests, reduce the number of lodgepole pines that have invaded the meadow since 1965, remove as many logs as is feasible, and burn most of the dead fuels (i.e., unusable logs, standing dead trees, branches, cones and fine fuels) that have accumulated. After initial treatment, which should take 5-10 years, fuel loads in this zone will be greatly diminished, the dry meadow will be enlarged, and the Jeffrey pine forest will be more open (see Desired Future Conditions). This combination of impacts will create conditions in the bottom of Little Valley that will greatly reduce the risk of a catastrophic wildfire. Equally important, our treatments will create conditions that will allow fire fighters to work safely on the ground within Little Valley to combat a wildfire in the region (Stephens and Ruth 2005).

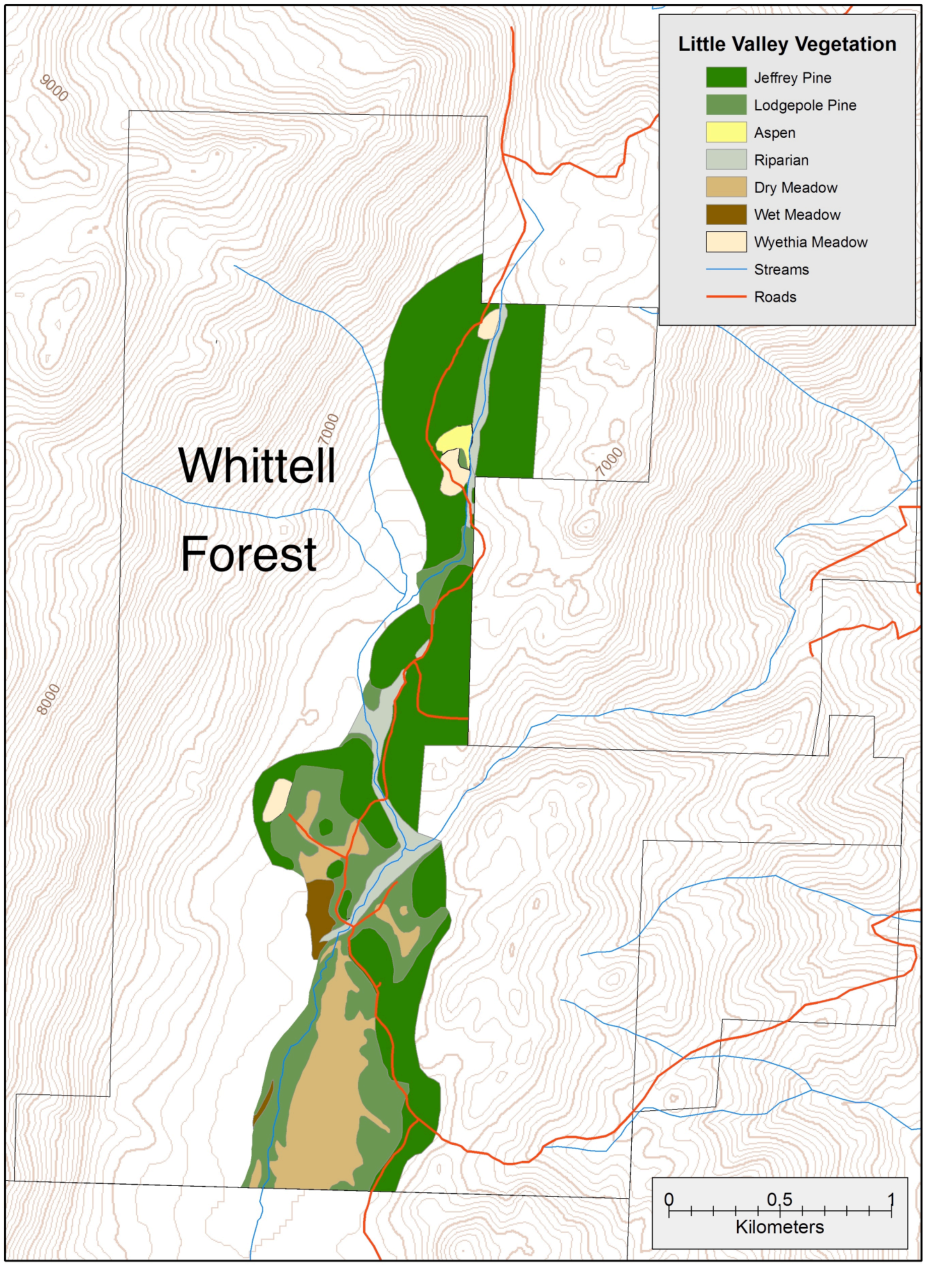


Fig. 30. Map of the Whittell Forest showing the forest and meadow areas targeted for treatment. Generally, treatment areas are within 150 m of a road in Little Valley or are part of the meadow.

If such treatments are not conducted, fire-fighting personnel might not be permitted to enter the valley in the event of a nearby wildfire because the region's topography and current fuel loads potentially make it a high-risk environment for fire fighters.

On a larger scale, similar fuel treatments are planned for the Toiyabe National Forest north and east of the Whittell Forest (Fig. 31) as part of the North Washoe Valley Wildfire Risk Reduction and Ecosystem Enhancement Project (Loomis et al. 2004). This initiative includes strategically placed land area treatments on 2500 acres of forest, brushland, and riparian zones. Many of the treatment units planned by the Forest Service are contiguous with those described here. Treatments in forested stands will involve mechanical thinning of mostly smaller trees to decrease the amount of ladder fuels and increase the spacing between trees. All of the largest trees will be left on site. The target canopy cover will be 40% in treated areas. Trees will be harvested through a combination of ground-based logging equipment and helicopters. These treatments will be followed by broadcast or underburning to remove surface fuels. Brushfields will be treated with mechanical equipment to produce chips that will be removed or scattered to decompose on site.

Like the proposed treatments for the Whittell Forest, the US Forest Service treatments will serve as "speed bumps" if a fire occurs, acting to slow the spread of fire and cause fire to drop from the crowns of trees to the ground (e.g., Agee and Skinner 2005). This will provide safer firefighting conditions and return fire to a more natural role in the ecosystem. Implementation of the US Forest Service project is scheduled to begin in fall 2005. Other fuel reduction projects are underway on private lands and at Davis Creek and Bowers Mansion County Parks.

Desired Future Conditions

For the Jeffrey pine forests treated in Little Valley, we aim to create a forest that is more resilient to future wildfire. A fire-resilient forest is one that can experience a fire without suffering high levels of tree mortality (Brown et al. 2004). This is because the architecture of the forest and the available fuel cannot, except under the most extreme conditions, support an intense fire, so that fire severity is low. Initial treatments emphasizing thinning of saplings and pole-sized trees (i.e., thinning from below) and prescribed fire will reduce fuels and stand density. After initial treatment and fuel reduction in these forests, future prescribed fire treatments will be more similar to low-intensity, natural fires that the Carson Range experienced during the presettlement era. We aim to create a range of forest conditions that are better adapted to the fire regime, climate and pathogens of the region. It is our goal to create a forest structure and disturbance regime that approximates presettlement conditions, not simply because those conditions existed historically, but because they are sustainable (i.e., resilient to insect-infestation and wildfire) under current climatic and land-use conditions (Arno and Fiedler 2005).

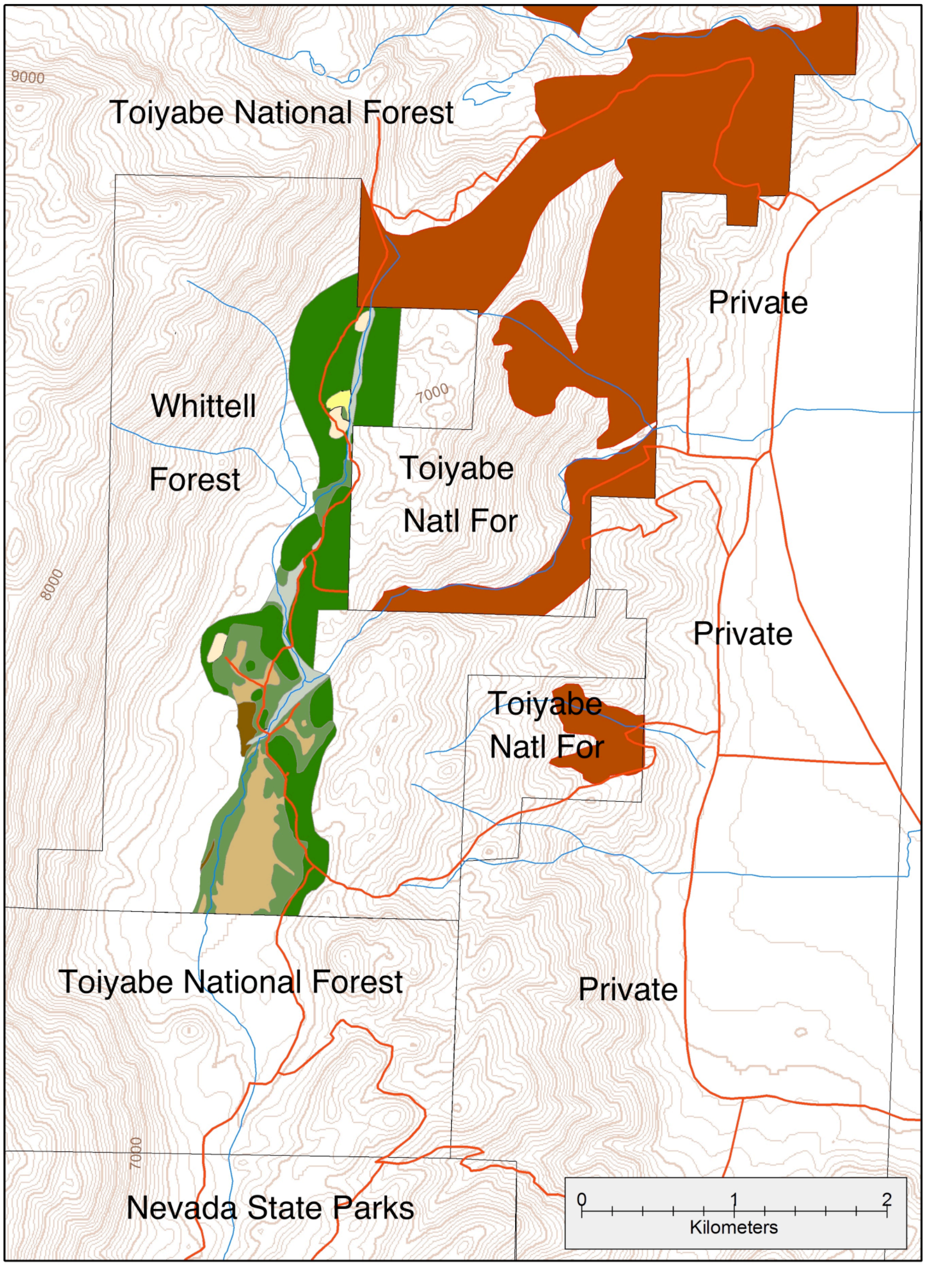


Fig. 31. The arrangement of the areas to be treated in the Whittell Forest relative to areas targeted for treatment as part of the US Forest Service's Northern Washoe Valley Wildfire Risk Reduction and Ecosystem Enhancement Project (red). To the south of the Whittell Forest, the Toiyabe National Forest was thinned in the late 1980s. Together, these treated areas will form a continuous zone over 9 km long.

The following principles will be followed as we prepare treatment units. Fig. 32 helps to illustrate and clarify these points.

1. Reduce ground and surface fuels. Burning branches, twigs, needles, cones, saplings, decadent shrubs, logs, and other downed woody debris during prescribed fires ensures that these fuels will be unavailable, or greatly reduced, if a wildfire occurs. Reducing ground and surface fuels will limit flame length of a wildland fire, making it more difficult for a fire to enter the forest canopy.

2. Reduce ladder fuels. Ladder fuels include brush, small live trees, standing dead woody debris, and dead lower limbs under or near mature canopy trees. A ground fire can use ladder fuels to enter the forest canopy, creating a crown fire. We will eliminate ladder fuels in treatment areas by cutting small trees and woody debris under mature trees before prescribed fire treatments.

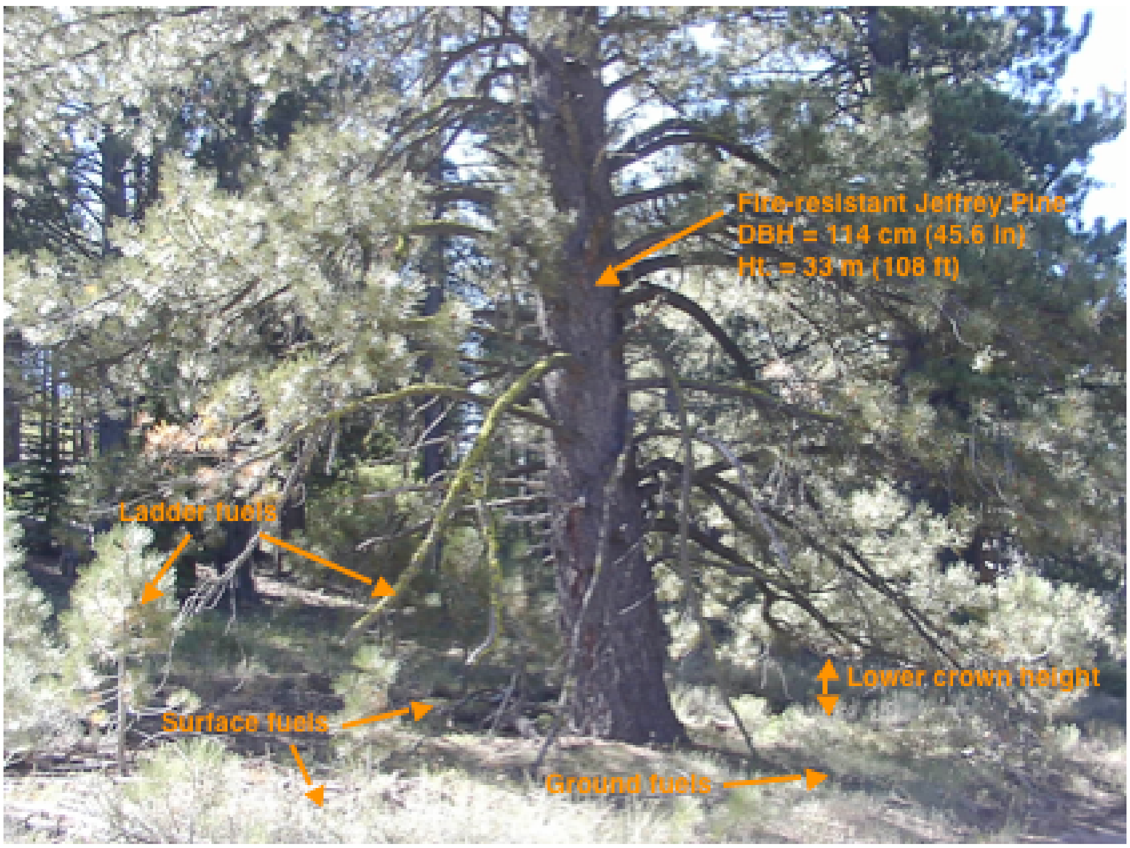


Fig. 32. An illustration of several fuel types. Ground fuels consist of litter and duff on the ground surface and usually do not represent a serious fire risk. Surface fuels include owned woody debris, herbaceous cover, and shrubs; when these accumulate, they can be hazardous fuels. Ladder fuels are saplings, small trees, and dead branches that provide vertical continuity between surface fuels and the tree canopy. Crown fuels are those in the overstory. When the lower crown is close to the ground, surface fire can enter the canopy.

3. Increase the height of crown fuels. The lower branches of mature trees in presettlement pine forests were often 10 m or more above the ground, but in many extant forests in the Carson Range the lowest branches of mature trees are often <2 m above the ground. The current condition greatly increases the likelihood of a surface fire becoming a crown fire. We will reduce the likelihood of canopy torching by pruning the lower branches of mature trees in treatment areas. The heat from prescribed fire will likely kill some of the lower branches of trees, resulting in a gradual increase in lower canopy height.

4. Decrease crown density. Tree density in portions of the treatment areas is too high. High tree density results in the crowns of many trees touching each other, a condition that can facilitate spread of a crown fire. We will reduce tree density and crown connectivity by strategically removing small- to pole-sized trees where they connect the canopies of mature trees.

5. Preserve large, fire-resistant Jeffrey pines. Jeffrey pines with DBHs (diameters at breast height) >75 cm are abundant and trees >100 cm are fairly common in Little Valley. These trees will form the nucleus of future 'old-growth' forests in Little Valley. We will pay special attention to preserving these trees in treated areas by applying the above four treatment principles in the growth' trees. We will use the same practices to preserve the very large, fire-sensitive white firs and lodgepole pines on treatment areas, which are much less numerous.

In Jeffrey pine-white fir forest, our goal is to reduce tree density to an average of less than 100 trees/acre (less than 250 trees/hectare). Eventually, most of the basal area will be in larger trees (>75 cm DBH). Most small white fir trees will be selectively removed because they contribute to ladder fuels, but mature (>50 cm) white firs will be retained. We do not expect to reach these goals in one treatment cycle. Repeated treatments at intervals of 10-15 years will gradually move conditions in the treatment areas toward the desired conditions.

With regard to the meadow, we intend to reestablish continuous meadow habitat from our south boundary north to and somewhat beyond the campground (to ≈39°15‘37“ N latitude) as a fuel break. The meadow, which is dominated by grasses, sedges, and forbs is a natural fuel break because of the very low fuel density. The meadow (potentially) is ≈2.5 km long and 200-500 m wide. The meadow is a strategically important zone in our program to reduce the risk of wildfire. To achieve this goal, we will eliminate (with mechanical treatment and pile burning) all small to medium-sized lodgepole pines (DBH <25 cm in 2005) that have invaded the meadow since the 1960s. We anticipate that meadow vegetation will recolonize the area quickly following tree removal. Removing lodgepole pines from along the south fork of Franktown Creek will also allow for the expansion of riparian habitat (willows, alders, and aspen). This should improve wildlife habitat and help to stabilize the stream bank (i.e., reduce erosion).

Much of the lodgepole pine forest on the east side of the valley is divided into several stands. Some of these stands are very dense and would be dangerous to treat with prescribed fire. Our main strategy will be to isolate these dense stands by strategically cutting certain small trees to increase the size of the gap between stands.

In the event of a wildfire, the greater isolation of these stands will help prevent fire from spreading across the valley.

Treatment Units

We have divided the area to be treated during the first 10-15 years of this project (Fig. 30) into treatment units. These treatment units are illustrated on recent (June 2005) aerial photographs (Figs. 33-36) and the characteristics of the units and actions to be taken in each unit are briefly summarized on Tables 2-4. There are 22 Jeffrey pine forest units (designated JP-1 to JP-22), eight lodgepole pine forest units (LP-1 to LP-8), and 16 units where young lodgepole pines have invaded the meadow (LPm-1 to LPm-16), for a total of 46 treatment units. We defined units based on characteristics of the vegetation, the treatment required, and convenient boundaries (e.g., roads, stream, meadow edge) that can serve as fuel breaks. Characteristics of the units vary greatly but some generalizations can be made.

Jeffrey pine units consist of open to closed-canopied Jeffrey pine forest. Young Jeffrey pines, white firs, and some lodgepole pines are numerous and thriving in the understory of these forests. Many of these young trees are forming or have the potential to form dense thickets in the near future. These trees are stunting each other's growth, are probably interfering with the growth and health of overstory trees, and represent dangerous ladder fuels. In more dense stands, pine bark beetles have attacked (in the mid 1990s) and killed clusters of 5 to more than 100 trees, which have fallen and form dense concentrations of dry fuel. About 24 sites with clusters of beetle-killed-trees (Fig. 18) are known in the Jeffrey pine treatment areas, most prominently in the southern units (e.g., JP-2, JP-3, JP-4 and JP-6). Standing dead and recently fallen dead trees are common. Other fuels, consisting of fallen branches, cones, and thick deposits of needle litter, are distributed patchily across treatment units. Shrub cover is scant in shaded areas, and, in more sunny areas, many shrubs are decadent.

Most lodgepole pine forests in the treatment area are over-mature and crowded, making them very difficult to treat (e.g., LP-2, Fig. 33). This habitat has burned in the past at intervals of 50-80 years (Parker 1986), so most stands are long overdue for a fire. Dense stands have a rich supply of standing dead trees and fallen logs. Other stands are more open, with few standing dead trees or fallen logs (e.g., LP-1). However, lodgepole pine seedlings and saplings are common in the understory, ensuring that these stands will be much more crowded in the not too distant future. Further, the branches of the mature trees often reach to within 1 m of the ground, making them very susceptible to torching during a ground fire.

The lodgepole pines that have invaded the meadow (Fig. 36) range in size from seedlings to small trees with DBHs (diameters at breast height) approaching 30 cm. The oldest of these young trees date from about 1965 when grazing was discontinued in the Whittell Forest. Most trees have DBHs <10 cm. In some areas, these trees are widely spaced and generally healthy with live branches that reach to the ground. In other areas, especially along the west bank of Franktown Creek, lodgepole pines grow very

Fig. 33. Aerial photograph of the southern portion of the Whittell Forest showing the locations and arrangement of eight Jeffrey pine treatment stands (Table 2) and five lodgepole pine treatment stands (Table 3). The Little Valley access road is in the lower right; the campground is in the extreme upper left corner.

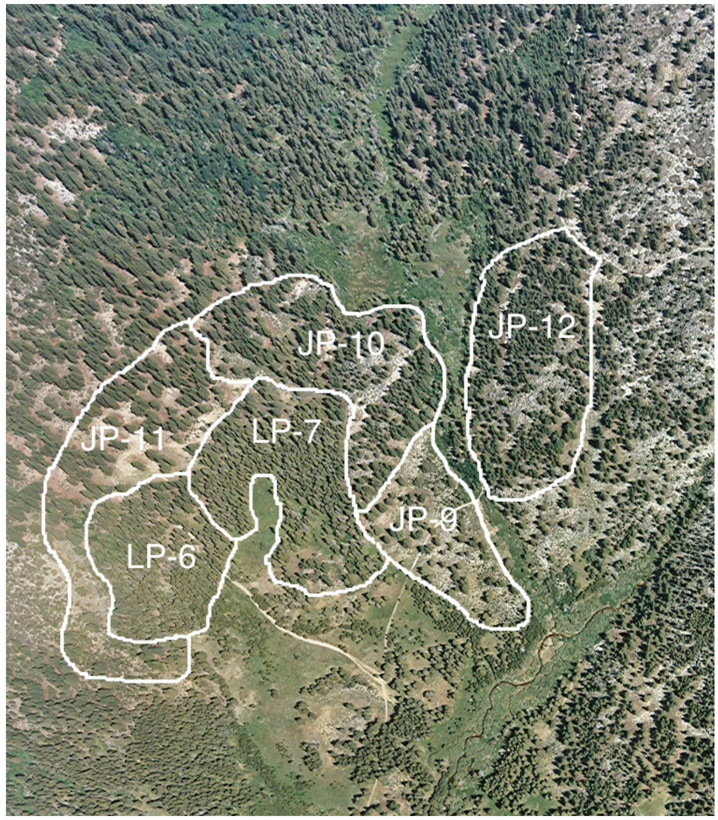


Fig.34. Aerial photograph of the central portion of the Whittell Forest showing the locations and arrangement of four Jeffrey pine treatment stands (Table 2) and two lodgepole pine treatment stands (Table 3). The campground is near the center of LP-6).

densely (>10 stems/m^2). These very crowded trees inhibit one another's growth, resulting in spindly, unhealthy trees with little foliage <3 m above the ground. There is usually little downed, woody debris in these areas; nearly all of the fuel is in the form of standing, live trees.

Treatment units have been assigned to one of three priority levels identifying urgency of treatment: high, medium, or low (Tables 2-4). High priority units are those with the highest quantities of downed, woody debris and ladder fuels and usually one or more beetle-killed-tree sites. These areas are also adjacent to the main north-south road through Little Valley, providing easy access to forest crews and fire-fighting equipment (e.g., JP-3). In the case of the meadow sites with invasive lodgepole saplings and small trees, treatment of the high priority sites (LPm 1, 3, 4, 6 and 7; Fig. 36) will reestablish the northern part of the meadow, which will act as a future firebreak. Medium priority units also have relatively high levels of downed, woody debris and ladder fuels, but are generally a little farther from the road (e.g., JP-6, LPm-16). Low priority units are those that have relatively little fuel but are threatened by an abundance of young seedlings and saplings that will result in a crowded, fire-prone site 10-20 years in the future if not treated. In many cases, these units are also more remote from the established road network (e.g., JP-22, LPm-11), making them somewhat more difficult to treat.

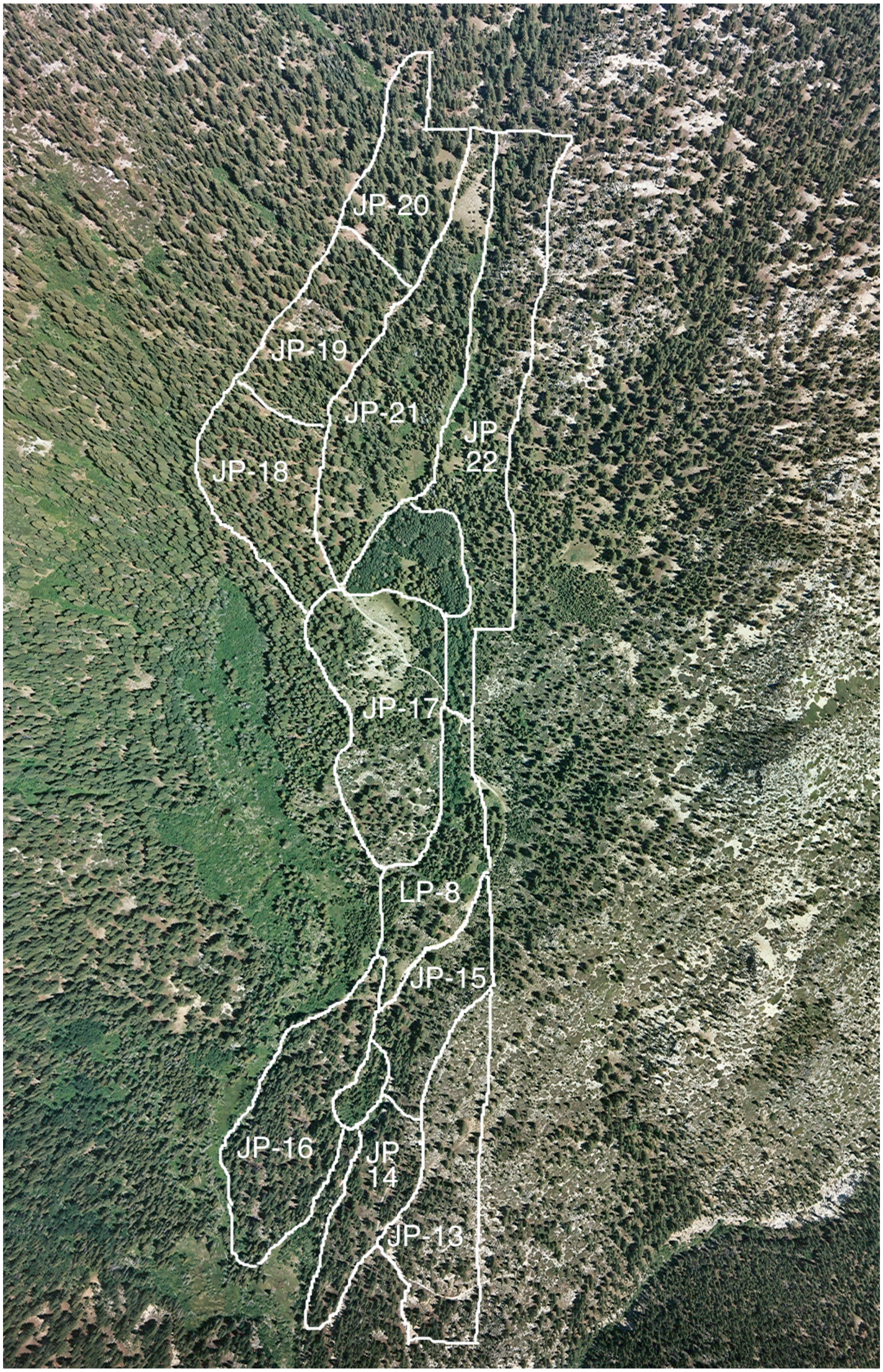


Fig. 35. Aerial photograph of the northern portion of the Whittell Forest showing the locations and arrangement of 10 Jeffrey pine treatment stands (Table 2) and one lodgepole pine treatment stand (Table 3). The access road runs up the middle of the map (e.g., between LP-8 and JP-15 and between JP-18 and JP-20.

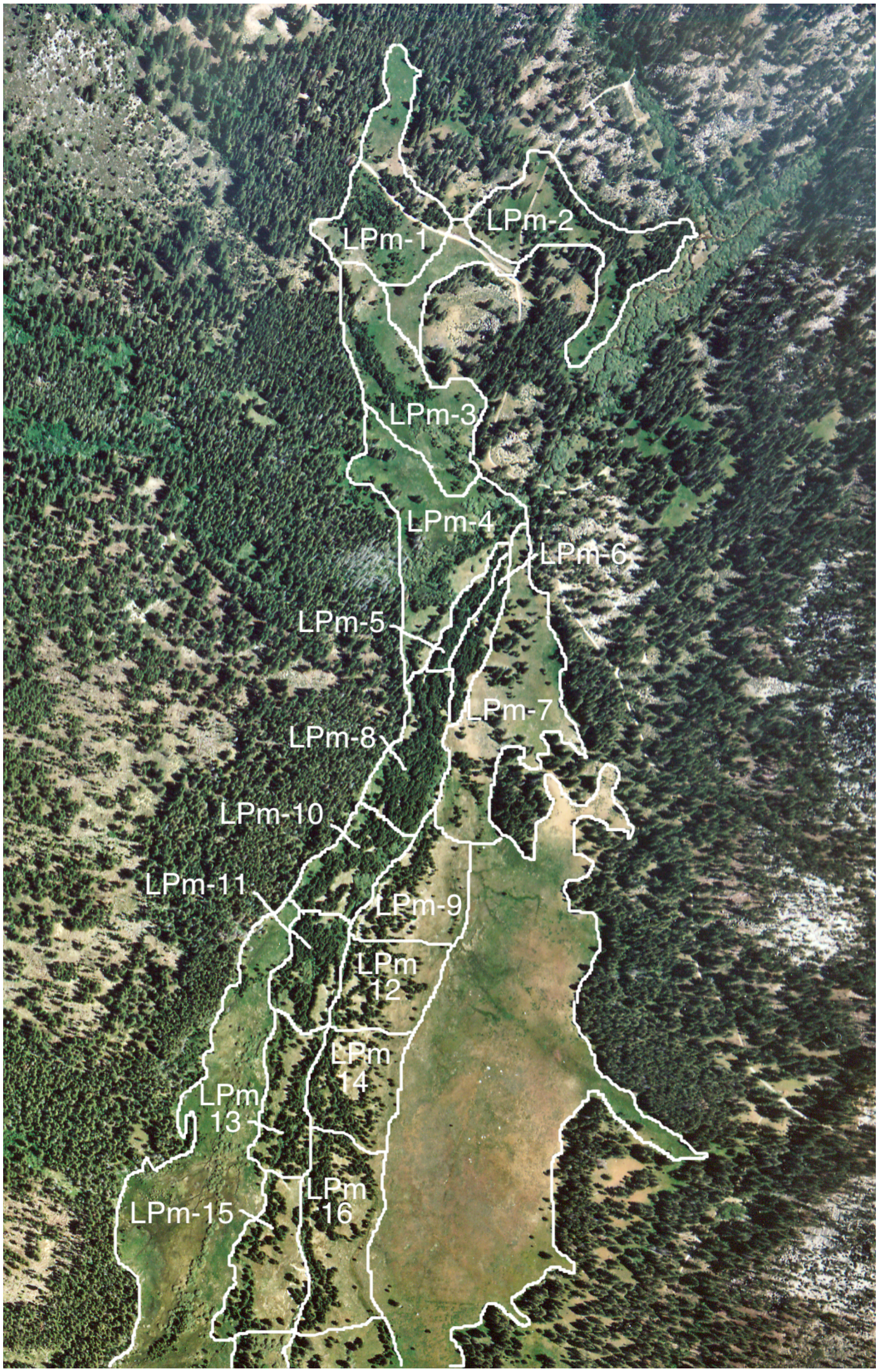


Fig. 36. Aerial photograph of the meadow in Little Valley. The outermost white line shows the extent of meadow vegetation in 1965; at that time, virtually no trees grew on the meadow (see Fig. 28). The dark green features are lodgepole pine trees that established on the meadow since ≈1965. The numbered white polygons are 16 young lodgepole pine stands targeted for treatment (Table 4).

Table 2. Treatment recommendations and characteristics of 22 mature Jeffrey pine stands. See Fig. 33-35.

Name	Size	Description	Priority
JP-1	11.9 acres	Thin young white firs, lodgepole pines and Jeffrey pines; cut standing dead trees; prepare downed woody debris; burn beetle-killed trees; broadcast burn	High
JP-2	8.2 acres	Thin pole-sized Jeffrey pines; cut standing dead trees; prepare downed woody debris; burn beetle-killed trees; broadcast burn	High
JP-3	4.9 acres	Thin young Jeffrey and lodgepole pines; cut standing dead trees; prepare downed woody debris; burn beetle-killed trees; broadcast burn	High
JP-4	7.5 acres	Thin young Jeffrey and lodgepole pines; cut standing dead trees; prepare downed woody debris; burn beetle-killed trees; broadcast burn	High
JP-5	11.7 acres	Thin young white firs, lodgepole pines and Jeffrey pines; cut standing dead trees; prepare downed woody debris; burn beetle-killed trees; broadcast burn	Medium
JP-6	6.3 acres	Thin young white firs, lodgepole pines and Jeffrey pines; cut standing dead trees; prepare downed woody debris; burn beetle-killed trees; broadcast burn	Medium
JP-7	8.3 acres	Thin young Jeffrey pines; pile burn	Low
JP-8	5.9 acres	Thin pole-sized Jeffrey pines; cut standing dead trees; prepare downed woody debris; burn beetle-killed trees; broadcast burn	Medium
JP-9	3.5 acres	Thin young Jeffrey pines; pile burn	Low
JP-10	6.2 acres	Thin pole-sized Jeffrey pines; cut standing dead trees; prepare downed woody debris; burn beetle-killed trees; broadcast burn	Medium
JP-11	6.4 acres	Thin pole-sized Jeffrey pines; cut standing dead trees; prepare downed woody debris; burn beetle-killed trees; broadcast burn	Medium

JP-12	6.4 acres	Thin pole-sized Jeffrey pines; cut standing dead trees; broadcast burn	Medium
JP-13	11.8 acres	Thin young Jeffrey pines; pile burn	Low
JP-14	6.4 acres	Thin pole-sized Jeffrey pines; cut standing dead trees; prepare downed woody debris; burn beetle-killed trees; broadcast burn	High
JP-15	6.7 acres	Thin pole-sized Jeffrey pines; pile burn	Medium
JP-16	12.6 acres	Thin pole-sized Jeffrey pines, white firs and lodgepole pines; cut standing dead trees; prepare downed woody debris; burn beetle-killed trees; broadcast burn	High
JP-17	15.3 acres	Thin pole-sized Jeffrey pines; pile burn	High
JP-18	10.5 acres	Thin pole-sized Jeffrey pines, white firs and lodgepole pines; cut standing dead trees; prepare downed woody debris; burn beetle-killed trees; broadcast burn	Medium
JP-19	9.4 acres	Thin young white firs, lodgepole pines and Jeffrey pines; cut standing dead trees; prepare downed woody debris; broadcast burn	Medium
JP-20	8.2 acres	Thin young white firs, lodgepole pines and Jeffrey pines; cut standing dead trees; prepare downed woody debris; broadcast burn	Medium
JP-21	17.9 acres	Thin young white firs, lodgepole pines and Jeffrey pines; cut standing dead trees; prepare downed woody debris; pile burn	Low
JP-22	14.6 acres	Thin pole-sized Jeffrey pines; pile burn	Low

Table 3. Treatment recommendations and characteristics of eight mature and over-mature lodgepole pine stands (not associated with meadow habitat). See Fig. 33-35.

Name	Size	Description	Priority
LP-1	16.5 acres	Thin young white firs, lodgepole pines and Jeffrey pines; cut standing dead trees; prepare downed woody debris; burn beetle-killed trees; broadcast burn Thin young white firs, lodgepole pines and Jeffrey pines; cut standing dead trees; prepare downed woody debris; burn beetle-killed trees; broadcast burn	Medium
LP-2	9.5 acres	No treatment planned; isolate	Low
LP-3	4.9 acres	Thin young lodgepole pines and cut standing dead trees in the north half of this area; pile burn; no treatment is south half; isolate	Low
LP-4	19.7 acres	In selected portions of this area along west and east edges, cut standing dead trees; prepare downed woody debris; pile burn	Medium
LP-5	7.1 acres	Thin young white firs, lodgepole pines and Jeffrey pines; cut standing dead trees; prepare downed woody debris; pile burn	Medium
LP-6	3.8 acres	Thin young white firs and lodgepole pines; cut standing dead trees; prepare downed woody debris; pile burn	Low
LP-7	5.6 acres	Thin young white firs and lodgepole pines; cut standing dead trees; prepare downed woody debris; pile burn	Low
LP-8	8.3 acres	Thin young white firs, lodgepole pines and Jeffrey pines; cut standing dead trees; prepare downed woody debris; pile burn	Low

Table 4. Treatment recommendations and characteristics of 16 young lodgepole pine stands (recently-invaded meadow habitat). See Fig. 36.

Name	Size	Description of treatments	Priority
LPm-1	7.6 acres	Cut all trees <30 cm DBH (diameter at breast height); remove logs 15-30 cm DBH; pile and burn branches and small trees	High
LPm-2	8.3 acres	Cut all trees <30 cm DBH; remove logs 15-30 cm DBH; pile and burn branches and small trees	Medium
LPm-3	7.9 acres	Cut all trees <30 cm DBH; remove logs 15-30 cm DBH; pile and burn branches and small trees	High
LPm-4	8.2 acres	Cut all trees <30 cm DBH; remove logs 15-30 cm DBH; pile and burn branches and small trees	High
LPm-5	1.3 acres	Cut all trees <30 cm DBH; remove logs 15-30 cm DBH; pile and burn branches and small trees	Medium
LPm-6	1.8 acres	Cut all trees <30 cm DBH; remove logs 15-30 cm DBH; pile and burn branches and small trees	High
LPm-7	10.2 acres	Cut all trees <30 cm DBH; remove logs 15-30 cm DBH; pile and burn branches and small trees	High
LPm-8	4.4 acres	Cut all trees <30 cm DBH; remove logs 15-30 cm DBH; pile and burn branches and small trees	Low
LPm-9	5.1 acres	Cut all trees <30 cm DBH; remove logs 15-30 cm DBH; pile and burn branches and small trees	Medium
LPm-10	3.8 acres	Cut all trees <30 cm DBH; remove logs 15-30 cm DBH; pile and burn branches and small trees	Low
LPm-11	3.4 acres	Cut all trees <30 cm DBH; remove logs 15-30 cm DBH; pile and burn branches and small trees	Low
LPm-12	4.3 acres	Cut all trees <30 cm DBH; remove logs 15-30 cm DBH; pile and burn branches and small trees	Medium
LPm-13	4.0 acres	Cut all trees <30 cm DBH; remove logs 15-30 cm DBH; pile and burn branches and small trees	Low
LPm-14	4.8 acres	Cut all trees <30 cm DBH; remove logs 15-30 cm DBH; pile and burn branches and small trees	Medium

LPm-15	5.0 acres	Cut all trees <30 cm DBH; remove logs 15-30 cm DBH; pile and burn branches and small trees	Medium
LPm-16	7.3 acres	Cut all trees <30 cm DBH; remove logs 15-30 cm DBH; pile and burn branches and small trees	Medium

Environmental Concerns

We are committed to reducing fuels and restoring ecosystem health to the Whittell Forest and simultaneously maintaining the property as a primitive area, as mandated by the Board of Regents. This means that we must conduct treatments while minimizing the unintended consequences of our actions. Soil compaction is one common unintended outcome of forest thinning, which we will minimize by requiring all vehicles (except under extraordinary circumstances) to be confined to existing roads or the shoulders of existing roads. All treatment activities will be conducted by personnel on foot with hand tools.

When fuel loads are high, as in some portions of the Whittell Forest, one consequence of prescribed fire is damage to the soil (i.e., sterilization). We hope to avoid this by encouraging broadcast burning (i.e., burning scattered fuels) rather than pile burning (i.e., fuels concentrated at relatively few sites). Scattered fuels burn in less time at lower temperatures than concentrated fuels, resulting in less potential damage to the soil.

There are no threatened or endangered plant or vertebrate species in the Whittell Forest, as far as we are aware (see Appendices for a complete list of plants, mammals and birds known to occur in the Whittell Forest). Some species of special interest, such as northern goshawks, do occur in the Whittell Forest. We believe that by conducting prescribed burns during the late fall and early winter, at a time when most species are either absent, dormant, or in non-breeding condition, we will minimize any impact of our activities on sensitive species. Over the longer term, we expect our treatments to improve ecosystem health and thereby improve habitat, potentially benefiting rare or uncommon species.

We are concerned about the effects of prescribed fire on riparian habitat and water quality. Aquatic systems are resilient to disturbances such as fire, especially when those fires are of low to moderate intensity. Prescribed fires generally have no appreciable effects on the quality of streams or groundwater (Richter et al. 1982, Minshall et al. 1997, Robinson et al. 2005). To prevent ash and nutrient from entering Franktown Creek and its tributaries, no burning will occur within 10 m of stream banks or riparian zones. Thinning of lodgepole pines growing on the meadow will be done so as to avoid trampling the meadow and streamside vegetation. Thinning of lodgepole pine on the meadow will be conducted during the late fall when the meadow is dry (i.e., less sensitive to compaction) and herbaceous plants are dormant (i.e., less sensitive to trampling).

Little Valley has significant archaeological resources, which need to be protected. Although fire, either wild or prescribed, is unlikely to directly harm the historic roads of Little Valley, firefighting equipment, particularly bulldozers, and post fire erosion could cause severe damage. Similarly, there are a number of archaeological sites, including the remains of several buildings, which could be significantly damaged during firefighting operations or preparations for prescribed burns. A more thorough inventory of culturally significant sites in Little Valley should be undertaken to ensure compliance with federal and state regulations concerning cultural resource protection and assure the survival of existing cultural resources. New sites are likely to be discovered after the prescribed fire treatments. Because the burns will improve access to and increase the visibility of sites, an intensive archaeological survey should be undertaken after prescribed burns in Little Valley.

Fire Prescriptions and Permits

Nevada Division of Forestry (NDF) personnel or other qualified entities expressly approved by NDF/UNR will conduct all prescribed burns. All broadcast burns (Fig. 37) and all pile burns conducted by NDF will be conducted under prescription. Prescriptions will be written by NDF personnel in consultation with a Whittell Board representative. Prescriptions will describe clearly the treatment unit to be burned, goals of the treatment, preburn preparation of the site, how the burn will be executed, the climatic conditions under which the burn can occur (a 'go-no go checklist'), the equipment and personnel

Fig. 37. Prescribed fire.

that will be on-site during the burn, predicted fire behavior, post-burn surveillance and 'mopping-up' procedures, and contingency plans for escaped fires. NDF personnel will obtain an air-quality permit from Washoe County and prescriptions will comply with Washoe County Air Quality regulations. Each treatment unit will have a separate prescription. Prescriptions will be prepared well before treatment and will be made available for public comment.

Qualified university personnel may conduct pile burns during the non-fire season under permit from the Nevada Division of Forestry. In late fall, winter, and early spring, sanitation pile burning can be conducted without a prescription. A pile burn, in this context, is defined as the burning of an isolated pile (not to exceed 3 m in height) of brush, to include dead and dry downed woody debris, branches, small-diameter logs and trees, and foliage. A burn permit will be obtained from NDF and an air-quality permit from Washoe County. Pile burns will be conducted only under cool, wet conditions and after the first winter snow, when the air temperature is $<60°F$, wind speed <10 mph, relative humidity $>25\%$, and soil water content $>3\%$. Ideally, pile burning will occur when there is snow on the ground. The Bowers Mansion NDF Fire Station and Sierra Front Interagency Dispatch Center will be notified before pile burning occurs.

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Appendices

Appendix 1. Vascular plants of the Whittell Forest and Wildlife Area originally compiled by Arnold Tiehm and Hugh N. Mozingo in 1976 (Little Valley Newsletter, Research Contribution No.1).

CALAMOPHYTA
Equisetaceae - Horsetail Family
Equisetum arvense L. (Common Horsetail)

PTEROPHYTA
Aspidiaceae - *Ladyfern Family*
Athyrinm filix-femina (L.) Roth var. *californicum* Butters (California Ladyfern)
Cystopteris fragilis L.) Bernh. (Fragile Fern)

Pteridaceae - Fern Family
Aspidotis densa (Hook.) Lellinger (Indian's Dream)
Cheilanthes gracillima D.C. Eaton (Lace Fern)
Pellaea bridgesii Hook. (Bridges' Cliff Brake)
Pteridium aquilinum (L.) Kuhn var. *pubescens* Underw. (Western Bracken Fern) .

CONIFEROPHYTA
Cupressaceae - Cypress Family
Calocedrus decurrens (Torr.) Florin (Incense Cedar)
Juniperus occidentalis Hook. ssp. *australis* Vasek (Western Juniper)

Pinaceae - Pine Family
Abies concolor (Gord. & Glend.) Lindl. (White Fir)
Abies magnifica A.Murr. (Red Fir)
Pinus albicaulis Engelm. (Whitebark Pine)
Pinus jeffreyi Grev. & Balf (Jeffrey Pine)
Pinus lambertiana Dougl. (Sugar Pine)
Pinus monticola Dougl. (Western White Pine)
Pinus conorta Grev. & Balf. (Lodgepole Pine)
Tsuga mertensiana (Bong.) Carr. (Mountain Hemlock)

ANTHOPHYTA
DICOTYLEDONS
Aceraceae - Maple Family
Acer glabrum Torr. var. *torreyi* (Greene) Smiley (Mountain Maple)

Apiaceae (Umbelliferae) – Parsley Family
Angelica breweri Gray (Brewer's Angelica)
Heracleum maximum Bartw. (Cow Parsnip)
Ligusticum grayi Coult. & Rose (Lovage)
Osmorhiza chilensis H. & A. (Sweet Cicely)
Osmorhiza occidentalis (Nutt.) Torr. (Western Sweet Cicely)
Perideridia bolanderi (Gray) Nelson & Macbr. (Bolander's Yampah)
Perideridia lemmonii (Coult. & Rose) Chuang & Constance (Lemmon's Yampah)
Perideridia parishii (Coult. & Rose) Nelson & Macbr. ssp. *latifolia* (Gray) (Parish's Yampah)
Sanicula graveolens Poepp. (Sierra Sanicle)
Sphenosciadium capitellatum Gray (Button Parsley)

Apocynaceae - Dogbane Family

Apocynum pumilum (Gray) Greene (Dogbane)

Asteraceae (Compositae) - Aster Family

Achillea lanulosa Nutt. (Yarrow)
Agoseris glauca (Pursh) Greene var. *monticola* (Greene) Q. Jones (Mountain Dandelion)
Agoseris heterophylla (Nutt.) Greene (Annual Mountain Dandelion)
Agoseris retrorsa (Benth.) Greene (Spear-leaved Mountain Dandelion)
Anaphalis margaritacea (L.) Benth. (Pearly Everlasting)
Antennaria geyeri Gray (Geyer's Pussytoes)
Antennaria rosea Greene (Rosy Everlasting)
Arnica chamissonis Less. ssp. *foliosa* (Nutt.) Maguire (Hoary Arnica)
Arnica chamissonis var. *incana* (Gray) Hult. (Hoary Arnica)
Arnica parryi Gray ssp. *sonnei* (Greene) Maguire (Parry's Arnica)
Artemisia arbuscula Nutt. (Low Sagebrush)
Artemisia douglasiana Bess. (Douglas' Mugwort)
Artemisia tridentata Nutt. (Basin Sagebrush)
Aster adscendens Lindl. (Long-leaved Aster)
Aster alpigenus (T. & G.) Gray ssp. *andersonii* (Gray) Onno (Alpine Aster)
Aster eatonii (Gray) Howell (Eaton's Aster)
Aster integrifolius Nutt. (Thickstem Aster)
Aster occidentalis (Nutt.) T. & G. (Western Aster)
Balsamorhiza sagittata (Pursh) Nutt. (Arrowleaf Balsam Root)
Chaenactis alpigena S. W. Sharsm. (Chaenactis)
Chaenactis douglasii (Hook.) H. & A. var. *rubricaulis* (Rydb.) Ferris (Hoary Chaenactis)
Chrysopsis breweri Gray (Golden Aster)
Chrysothamnus nauseosus (Pall.) Britton ssp. *albicaulis* (Rubber Rabbitbrush)
Chrysothamnus parryi (Gray) Greene ssp. *nevadensis* (Gray) (Parry's Rabbitbrush)
Cichorium intybus L. (Chicory)
Cirsium andersonii (Gray) Petr. (Anderson's Thistle)
Cirsium vulgare (Savi) Ten. (Bull Thistle)
Crepis acuminata Nutt. (Long-leaved Hawksbeard)
Crepis occidentalis Nutt. (Western Hawksbeard)
Erigeron breweri Gray (Brewer's Daisy)
Erigeron coulteri Porter (Coulter's Daisy)
Erigeron divergens T. & G. (Diffuse Daisy)
Erigeron inornatus (Gray) Gray (California Rayless Daisy)
Erigeron nevadincola Blake (Nevada Daisy)
Erigeron peregrinus (Pursh) Greene ssp. *callianthemus* (Greene) Cronq. (Daisy)
Erigeron peregrinus ssp. *callianthemus* var. *angustifolius* (Gray) Cronq. (Daisy)
Eriophyllum lanatum (Pursh) Forbes var. *integrifolium* (Hook.) Smiley (Oregon Sunshine)
Eupatorium occidentale Hook. (Western Eupatorium)
Gnaphalium microcephalum Nutt. (Slender Cudweed)
Gnaphalium palustre Nutt. (Lowland Cudweed)
Haplopappus bloomeri Gray (Bloomer's Goldenweed)
Haplopappus lanceolatus (Hook.) T. & G. (Lanceleaf Goldenweed)
Haplopappus suffruticosus (Nutt.) Gray (Single-head Goldenweed)
Helianthus annuus L. ssp. *lenticularis* (Dougl.) Ckll. (Common Sunflower)
Hieracium albiflorum Hook. (White Flowered Hawksbeard)
Hieracium horridum Fries (Shaggy Hawksbeard)
Lactuca serriola L. (Prickly Lettuce)
Lygodesmia spinosa Nutt. (Thorny Skeleton Weed)
Machaeranthera canescens (Pursh) Gray (Hoary Aster)

Madia elegans D. Don (Common Madia)
Madia glomerata Hook. (Mountain Tarweed)
Madia gracilis (Sm.) Keck (Slender Tarweed)
Madia minima (Gray) Keck (Pygmy Madia)
Malacothrix floccifera (DC.) Blake (Mountain Dandelion)
Microseris nutans (Hook.) Sch. Bip. (Nodding Microseris)
Senecio integerrimus Nutt. var. *exaltatus* (Nutt.) Cronq. (Single-stemmed Groundsel)
Senecio triangularis Hook. (Arrowleaf Groundsel)
Solidago canadensis L. ssp. *elongata* (Nutt.) Keck (Goldenrod)
Stephanomeria tenuifolia (Torr.) Hall (Skeletonweed)
Taraxacum officinale Wiggers (Common Dandelion)
Tetradymia canescens DC. (Horsebrush)
Tragopogon dubius Scop. (Salsify)
Wyethia mollis Gray (Mule-Ears)

Betulaceae - Birch Family
Alnus tenuifolia Nutt. (Mountain Alder)

Boraginaceae - Borage Family
Cryptantha affinis (Gray) Greene (Common Cryptantha)
Cryptantha ambigua (Gray) Greene (Basin Cryptantha)
Cryptantha simulans Greene (Pine Cryptantha)
Cryptantha torreyana (Gray) Greene (Torrey's Cryptantha)
Hackelia micrantha (Eastw.) J. L. Gentry (Mountain Forget-me-not)
Hackelia velutina (Piper) Jtn. (Velvety Stickseed)
Mertensia ciliata (James) G.Don var. *stomatechoides* (Kell) Jeps. (Mountain Bluebells)
Plagiobothrys hispidulus (Greene) Jtn. (Mountain Popcorn Flower)
Plagiobothrys torreyi (Gray) Gray (Torrey's Popcorn Flower)

Brassicaceae (Cruciferae) – Mustard Family
Arabis divaricarpa A. Nels. (Rock Cress)
Arabis glabra (L.) Bernh. (Tower Mustard)
Arabis holboellii Hornem. var. *pinetorum* (Tides.) Roll. (Holbell's Rock Cress)
Arabis holboellii var. *retrofracta* (Grah.) Rydb. (Holbell's Rock Cress)
Arabis platysperma Gray (Broad-seeded Rock Cress)
Arabis platysperma var. *howellii* (Wats.) Jeps. (Broad-seeded Rock Cress)
Arabis repanda Wats. (Wavy-leaved Rock Cress)
Barbarea orthoceras Ledeb. (Winter Cress)
Capsella bursa-pastoris (L.) Medic. (Shepherd's Purse)
Cardamine breweri Wats. (Bitter Cress)
Cardamine lyallii Wats. (Lyall's Cardamine)
Descurainia californica (Gray) O. E. Schulz (Tansy Mustard)
Descurainia richardsonii (Sweet) O. Schulz ssp. *incisa* (Engelm.) (Mountain Tansy-mustard)
Descurainia richardsonii ssp. *viscosa* (Rydb.) Detl. (Mountain Tansy-mustard)
Descurainia sophia (L.) Webb (Flixweed)
Draba asterophora Pays. (Draba) [Rare plant]
Draba stenoloba Ledeb. var. *nana* (O. E. Schulz) C. L. Hitchc. (Alaska Whitlow-grass)
Draba verna L. (Spring Whitlow-grass)
Erysimum perenne (Wats.) Abrams (Sierra Wall Flower)
Lepidium virginicum L. var. *pubescens* (Greene) Thell. (Wild Pepper-grass)
Rorippa curvisiliqua (Hook.) Bessev (Western Yellow Cress)

Caprifoliaceae - Honeysuckle Family
Sambucus caerulea Raf. (Blue Elderberry)
Symphoricarpos acutus (Gray) Dieck. (Snowberry)
Symphoricarpos vaccinioides Rydb. (Mountain Snowberry)

Caryophyllaceae - Pink Family
Arenaria congesta Nutt. var. *subcongesta* (Wats.) Wats. (Capitate Sandwort)
Arenaria kingii (Wats.) Jones var. *glabrescens* (Wats.) Maguire (King's Sandwort)
Arenaria nuttallii Pax ssp. *fragilis* Maguire & Holmgren (Nuttall's Sandort)
Cerastium vulgatum L. (Mouse-ear Chickweek)
Sagina saginoides (L.) Karst. var. *hesperia* Fern. (Arctic Pearlwort)
Silene douglasii Hook. (Douglas' Campion)
Silene montana Wats. (Mountain Catchfly)
Stellaria crispa Cham. & Schlecht. (Starwort)
Stellaria longipes Goldie (Long-stalked Starwort)

Chenopodiaceae - Goosefoot Family
Chenopodium atrovirens Rydb. (Pinyon Goosefoot)
Chenopodium dessiccatum A. Nels. var. *leptophylloides* (J. Murr) (Dryland Goosefoot)
Kochia scoparia (L.) Schrad. (Summer Cypress)
Monolepis nuttalliana (Schult.) Greene (Nuttall's Monolepis)

Cornaceae – Dogwood Family
Cornus stolonifera Michx. (Creek Dogwood)

Ericaceae – Heather Family
Arctostaphylos nevadensis Gray (Pine Mat Manzanita)
Arctostaphylos patula Greene (Greenleaf Manzanita)
Phyllodoce breweri (Gray) Heller (Red Heather)
Vaccinium occidentale Gray (Western Blueberry)

Fabaceae (Leguminosae) – Pea Family
Astragalus sp. (Locoweed)
Lathyrus lanszwertii Kell. (Nevada Pea)
Lotus nevadensis Greene (Sierra Nevada Lotus)
Lotus purshianus (Benth.) Clem. & Clem. (Spanish Clover)
Lupinus andersonii Wats. (Anderson's Lupine)
Lupinus meionanthus Gray (Lake Tahoe Lupine)
Lupinus polyphyllus Lindl. ssp. *superbus* (Heller) Munz (Blue-pod Lupine)
Lupinus sellulus Kell. (Prairie Lupine)
Trifolium longipes Nutt. ssp. *hansenii* (Greene) J. M. Gillett (Long-stalked Clover)
Trifolium monanthum Gray (Mountain Carpet Clover)
Trifolium repens L. (White Clover)
Trifolium wormskioldii Lehm. (Cow Clover)

Fagaceae – Beech Family
Castanopsis sempervirens (Kell.) Hjelmquist (Sierra Bush Chinquapin)
Quercus vaccinifolia Kell. (Huckleberry Oak)

Gentianaceae – Gentian Family
Gentiana newberryi Gray (Alpine Gentian)
Gentiana simplex Gray (Hiker's Gentian)

Geraniaceae – Geranium Family
Erodium cicutarium (L.) L. Her. (Filaree)

Hydrophyllaceae – Waterleaf Family
Hesperochiron californicus (Benth.) Wats. (California Hesperochiron)
Nemophila spatulata Cov. (Sierra Nemophila)
Phacelia hastata Dougl. (Cordilleran Phacelia)
Phacelia heterophylla Pursh ssp. *virgata* (Greene) Heckard (Wand Phacelia)
Phacelia humilis T. & G. (Humble Phacelia)
Phacelia hydrophylloides Torr. (Waterleaf Phacelia)
Phacelia ramosissima Dougl. (Branching Phacelia)

Hypericaceae – St. John's Wort Family
Hypericum anagalloides Cham. & Schlecht. (Tinker's Penny)
Hypericum formosum HBK. var. scouleri (Hook.) Coult. (St. John's Wort)

Lamiaceae (Labiatae) – Mint Family
Agastache urticifolia (Benth.) Kuntze (Horse Mint)
Marrubium vulgare L. (Horehound)
Mentha arvensis L. (Field Mint)
Monardella odoratissima Benth. ssp. *glauca* (Greene) Epl. (Pennyroyal)
Prunella vulgaris L. ssp. *lanceolata* (Barton) Hult. (Self-heal)
Scutellaria galericulata L. (Marsh Skullcap)

Limnanthaceae – Meadow Foam Family.
Floerkea proserpinacoides Willd. (False Mermaid)

Loasaceae – Blazing Star Family
Mentzelia congesta (Nutt.) T. & G. (Flower Baskets)
Mentzelia congesta var. davidsoniana (Abrams) Macbr. (Flower Baskets)
Mentzelia dispersa Wats. (Watson's Stick-leaf)

Malvaceae – Mallow Family
Sidalcea multifida Greene (Sidalcea)
Sidalcea oregana (Nutt.) Gray ssp. *spicata* (Regel) C. L. Hitchc. (Oregon Sidalcea)

Onagraceae – Evening-primrose Family
Boisduvalia densiflora (Lindl.) Wats. (Dense-flowered Boisduvalia)
Circaea alpina L. var. *pacifica* (Asch. & Magnus) Jones (Enchanter's Nightshade)
Clarkia lassenensis (Eastw.) Lewis & Lewis (Lassen Clarkia)
Epilobium adenocaulon Hausskn. (Northern Willow-herb)
Epilobium angustifolium L. (Fireweed)
Epilobium breyistylum Barb. (Slender Willow-herb)
Epilobium exaltatum E. Drew (Willow-herb)
Epilobium glaberrimum Barb. (Smooth Willow-herb)
Epilobium oregonense Hausskn. (Oregon Willow-herb)
Epilobium paniculatum Nutt. (Annual Willow-herb)
Gayophytum diffusum T. & G. ssp. *parviflorum* Lewis & Szweykowski (Diffuse Gayophytum)
Gayophytum heterozygum Lewis & Szweykowski (Lumpy-podded Gayophytum)
Gayophytum racemosum T. & G. (Many-flowered Gayophytum)
Oenothera contorta Dougl. (Slender Evening-primrose)
Oenothera subacaulis (Pursh) Garret (Short-stemmed Evening-primrose)

Paeoniaceae – Peony Family
Paeonia brownii Dougl. (Western Peony)

Papaveraceae – Poppy Family
Argemone munita Dur. & Hilg. (Prickly Poppy)

Polemoniaceae – Phlox Family
Allophyllum integrifolium (Brand) A. & V. Grant (White False-gilia)
Allophyllum violaceum (Heller) A. & V. Grant (Loose-flowered Allophyllum
Collomia grandiflora Dougl. (Large-flowered Collomia)
Collomia linearis Nutt. (Narrow-leaved Collomia)
Eriastrum sparsiflorum (Eastw.) Mason (Few-flowered Eriastrum)
Gilia capillaris Kell. (Smooth-leaved Gilia)
Ipomopsis aggregata (Pursh) V. Grant (Scarlet Gilia)
Leptodactylon pungens (Torr.) Rydb. ssp. *pulchriflorum* (Brand) Mason (Prickly Phlox)
Linanthus ciliatus (Benth.) Greene (Bristly-leaved Linanthus)
Linanthus harknessii (Curran) Greene (Harkness' Linanthus)
Microsteris gracilis (Hook.) Greene (Annual Phlox)
Navarretia breweri (Gray) Greene (Brewer's Navarretia)
Navarretia divaricata (Torr.) Greene (Mountain Navarretia)
Navarretia propinqua Suksd. (Great Basin Navarretia)
Phlox diffusa Benth. (Spreading Phlox)
Phlox stansburyi (Torr.) Heller (Stansbury Phlox)
Polemonium caeruleum L. ssp. *amygdalinum* (Wherry) Munz (Jacob's Ladder)
Polemonium californicum Eastw. (California Polemonium)

Polygonaceae – Buckwheat Family
Eriogonum elatum Dougl. (Tall Buckwheat)
Eriogonum lobbii T. & G. (Lobb's Buckwheat)
Eriogonum marifolium T. & G. (Lobb's Wild Buckwheat)
Eriogonum nudum Dougl. (Naked-stemmed Buckwheat)
Eriogonum ovalifolium Nutt. var. *eximium* (Tides.) J. T. Howell (Cushion Buckwheat)
Eriogonum spergulinum Gray var. *reddingianum* (Jones) J. T. Howell (Spurry Buckwheat)
Eriogonum umbellatum Torr. var. *nevadense* Gand. (Sulfur-flower)
Eriogonum wrightii Torr. ssp. *subscaposum* (Wats.) S. Stokes (Wright's Buckwheat)
Polygonum aviculare L. (Common Knotweed)
Polygonum bistortoides Pursh. (American Bistort)
Polygonum douglasii Greene var. *latifolium* (Engelm.) Greene (Douglas' Knotweed)
Polygonum kelloggii Greene (Kellogg's Knotweed)
Polygonum minimum Wats. (Least Knotweed)
Polygonum phytolaccifolium Meissn. (Mountain Lace)
Polygonum shastense Brew. (Shasta Knotweed)
Rumex acetosella L. (Sheep Sorrel)
Rumex crispus L. (Curly Dock)
Rumex utahensis Rech. (Utah Dock)

Portulacaceae – Purslane Family
Calyptridium umbellatum (Torr.) Greene (Pussypaws)
Lewisia nevadensis (Gray) Rob. (Nevada Lewisia)
Montia chamissoi (Ledeb.) Dur. & Jacks. (Toad-lily)
Montia linearis (Dougl.) Greene (Linear-leaved Monia)
Montia perfoliata (Donn) Howell var. depressa (Gray) Jeps. (Miner's Lettuce)

Primulaceae – Primrose Family
Dodecatheon alpinum (Gray) Greene ssp. *majus* H. J. Thomps. (Alpine Shooting Star)

Pyrolaceae – Wintergreen Family
Chimaphila menziesii (R. Br.) Spreng. (Pipsissewa)
Pterospora andromedea Nutt. (Pinedrops)
Pyrola asarifolia Michx. var. *purpurea* (Bunge) Fern. (Wintergreen)
Pyrola picta Sm. (White-veined Wintergreen)
Pyrola secunda L. (One-sided Pyrola)
Sarcodes sanguinea Torr. (Snowplant)

Ranunculaceae – Buttercup Family
Aconitum columbianum Nutt. (Monkshood)
Aquilegia formosa Fisch. (Columbine)
Delphinium glaucum Wats. (Mountain Larkspur)
Delphinium nuttallianum Pritz. (Nuttall's Larkspur)
Delphinium sonnei Greene (Sonne's Larkspur)
Myosurus minimus L. ssp. *montanus* Campb. (Common Mouse-tail)
Ranunculus alismifolius Geyer var. *hartwegii* (Greene) Jeps. (Water Plantain Buttercup)
Ranunculus alismifolius var. *lemmonii* (Gray) L. Benson (Water Plantain Buttercup)
Ranunculus occidentalis Nutt. (Western Buttercup)
Ranunculus uncinatus D. Don (Hook-fruited Buttercup)
Thalictrum fendleri Engelm. (Meadow Rue)

Rhamnaceae – Buckthorn Family
Ceanothus cordulatus Kell. (Snow Brush)
Ceanothus prostratus Benth. (Mahala Mat)
Ceanothus velutinus Dougl. (Tobacco Brush)
Rhamnus rubra Greene (Sierra Coffeeberry)

Rosaceae – Rose Family
Amelanchier pallida Greene (Serviceberry)
Cercocarpus ledifolius Nutt. (Mountain Mahogany)
Fragaria virginiana L. ssp. *platypetala* Staudt. (Strawberry)
Geum macrophyllum Willd. (Large-leaved Avens)
Holodiscus boursieri (Carr.) Rehd. (Cliff Spray)
Horkelia fusca Lindl. ssp. *pseudocapitata* (Rhyb.) Keck (Pinewoods Horkelia)
Potentilla glandulosa Lindl. ssp. *hansenii* (Greene) Keck (Sticky Cinquefoil)
Potentilla gracilis Dougl. ssp. *nuttallii* (Lehm.) Keck (Northwest Cinquefoil)
Prunus andersonii Gray (Desert Peach)
Prunus emarginata (Dougl.) Walp. (Bitter Cherry)
Purshia tridentata (Pursh) DC. (Antelope Bitterbrush)
Rosa woodsii Lindl. var. *ultramontana* (Wats.) Jeps. (Mountain Rose)
Rubus parviflorus Nutt. (Thimble Berry)
Sorbus californica Greene (Mountain Ash)
Spiraea densiflora Nutt. (Sierra Spiraea)

Rubiaceae – Madder Family
Galium aparine L. (Bedstraw)
Galium bifolium Wats. (Mountain Bedstraw)
Galium trifidum L. var. *pusillum* Gray (Bedstraw)
Galium trifidum var. *subbiflorum* Wieg. (Bedstraw)
Kelloggia galioides Torr. (Kelloggia)

Salicaceae – Willow Family

Populus tremuloides Michx. (Quaking Aspen)
Populus trichocarpa T. & G. (Black Cottonwood)
Salix geyeriana Anderss. var. *argentea* (Bebb.) C. K. Schneid (Geyer's Willow)
Salix lasiandra Benth. (Yellow Willow)
Salix lasiolepis Benth. (Arroyo Willow)
Salix lemmonii Bebb (Lemmon's Willow)
Salix scouleriana Barr. (Scouler Willow)

Saxifragaceae – Saxifrage Family

Lithophragma glabrum Nutt. (Smooth Woodland-star)
Lithophragma parviflorum (Hook.) Nutt. (Woodland-star)
Mitella breweri Gray (Bishop's Cap)
Ribes cereum Dougl. (Blue Current)
Ribes divaricatum Dougl. var. *inerme* (Rydb.) McMinn (Straggly Gooseberry)
Ribes lasianthum Greene (Alpine Gooseberry)
Ribes nevadense Kell. (Sierra Currant)
Ribes viscosissimum Pursh var. *hallii* Jancz. (Sticky Currant)
Saxifraga aprica Greene (Sierra Saxifrage)
Saxifraga oregana Howell (Bog Saxifrage)

Scrophulariaceae – Figwort Family

Castilleja applegatei Fern. var. *fragilis* (Zeile) N. Holmgren. (Wavy-leaved Indian Paintbrush)
Castilleja miniata Dougl. (Common Indian Paintbrush)
Castilleja nana Eastw. (Little Indian Paintbrush)
Collinsia parviflora Dougl. (Blue Eyed Mary)
Mimulus breweri (Greene) Cov. (Brewer's Monkeyflower)
Mimulus guttatus Fisch. (Yellow Monkeyflower)
Mimulus lewisii Pursh (Lewis' Monkeyflower)
Mimulus mephiticus Greene (Monkeyflower)
Mimulus moschatus Dougl. (Musky Monkeyflower
Mimulus primuloides Benth. var. *pilosellus* (Greene) Smiley (Primrose Monkeyflower)
Mimulus suksdorfii Gray (Suksdorf's Monkeyflower)
Mimulus tilingii Regel (Creeping Monkeyflower)
Orthocarpus hispidus Benth. (Hairy Owls-clover)
Pedicularis groenlandica Retz. (Elephant Head)
Pedicularis semibarbata Gray (Pine Pedicularis)
Penstemon deustus Dougl. (Hot-rock Penstemon)
Penstemon gracilentus Gray (Slender Penstemon)
Penstemon newberryi Gray (Pride of the Mountain)
Penstemon procerus Dougl. ssp. *formosus* (A. Nels.) Keck (
Penstemon rydbergii A. Nels. (Meadow Penstemon)
Penstemon speciosus Dougl. (Showy Penstemon)
Verbascum thapsus L. (Common Mullein)
Veronica americana (Raf.) Schw. (American Brooklime)
Veronica peregrina L. ssp. *xalapensis* (HBK.) Penn. (Purslane Speedwell)
Veronica serpyl1ifolia L. var. *humifusa* (Dickson) Vahl (Thyme-leaved Speedwell)

Urticaceae – Nettle Family

Urtica serra Blume (Stinging Nettle)

Valerianaceae – Valerian Family
Valeriana capitata Pall. ssp. *californica* (Heller) F. G. Mey. (California Valerian)

Violaceae – Violet Family
Viola macloskeyi Lloyd (White Violet)
Viola purpurea Kell. ssp. *dimorpha* Baker & Clausen (Yellow Violet)

Viscaceae (Loranthaceae) – Mistletoe Family
Arceuthobium campylopodum Engelm. (Western Dwarf Mistletoe)

MONOCOTYLEDONS
Cyperaceae – Sedge Family
Carex amplifolia Boott (Ample-leaved Sedge)
Carex athrostachya Olney (Slender-beaked Sedge)
Carex aurea Nutt. (Golden Sedge)
Carex capitata L. (Artic Sedge)
Carex disperma Dewey (Two-seeded Sedge)
Carex douglasii Boott (Douglas' Sedge)
Carex exserta Mkze. (Short-hair Sedge)
Carex festivella Mkze. (Mountain Meadow Sedge)
Carex fissuricola Mkze. (Sedge)
Carex fracta Mkze. (Fragile-sheathed Sedge)
Carex heteroneura W.Boott (Sedge)
Carex integra Mkze. (Sedge)
Carex jonesii Bailey (Jones' Sedge)
Carex lanuginosa Michx. (Wooly Sedge)
Carex leporinella Mkze. (Sedge)
Carex leptopoda Mkze. (Sedge)
Carex multicostata Mkze. (Sedge)
Carex nebrascensis Dewey (Nebraska Sedge)
Carex nervina Bailey (Sedge)
Carex pachystachya Cham. (Chamisso Sedge)
Carex praegracilis W. Boott (Cluster Field Sedge)
Carex rossii Boott (Ross' Sedge)
Carex rostrata Stokes (Bottle Sedge)
Carex simulata Mkze. (Short-beaked Sedge)
Carex specifica Bailey (Sedge)
Carex subfusca W. Boott (Rusty Sedge)
Carex teneriformis Mkze. (Sierra Slender Sedge)
Eleocharis acicularis (L.) R. & S. (Slender Spike-rush)
Eleocharis macrostachya Britton (Common Spike-rush)
Eleocharis quinqueflora (F. X. Hartmann) O. Schwarz (Few-flowered Spike-rush)
Scirpus microcarpus Presl (Panicle Bulrush)

Iridaceae – Iris Family
Iris missouriensis Nutt. (Western Blue Flag)
Sisyrinchium idahoense Bickn. (Blue-Eyed Grass)

Juncaceae – Rush Family
Juncus abjectus F. J. Herm. (Peck's Dwarf Rush)
Juncus balticus Willd. (Wire Rush)
Juncus bryoides F. J. Herm. (Moss Rush)
Juncus bufonius L. (Toad Rush)

Juncus chlorocephalus Engelm. (Yellow-green Rush)
Juncus drummondii E. Mey. (Drummond's Rush)
Juncus ensifolius Wikstr. (Three-stamened Rush)
Juncus hemiendytus F. J. Herm. (Half-bracted Dwarf Rush)
Juncus longistylis Torr. (Long-styled Rush)
Juncus nevadensis Wats. (Sierra Rush)
Juncus parryi Engelm. (Parry's Wire Rush)
Juncus sphaerocarpus Nees. (Spiny Rush)
Luzula comosa E. Mey. (Hairy Wood Rush)
Luzula divaricata Wats. (Hairy Wood Rush)
Luzula subcongesta (Wats.) Jeps. (Hairy Wood Rush)

Lemnaceae – Duckweed Family
Lemna gibba L. (Duckweed)
Lemna trisulca L. (Duckweed)

Liliaceae – Lily Family
Allium bisceptrum Wats. (Twin-crest Onion)
Allium campanulatum Wats. (Sierra Onion)
Allium tribracteatum Torr. (Three-bracted Onion)
Allium validum Wats. (Swamp Onion)
Brodiaea hyacinthina (Lindl.) Baker (Wild Hyacinth)
Calochortus leichtlinii Hook. (Mariposa Lily)
Calochortus nuttallii Torr. var. *bruneaunis* (Nels. & Macbr.) Ownbey (Sego Lily)
Camassia quamash (Pursh) Greene ssp. *breviflora* Gould (Blue Camas)
Fritillaria atropurpurea Nutt. (Frittillary)
Lilium parvum Kell. (Alpine Lily)
Muilla transmontana Greene (Great Basin Muilla)
Smilacina stellata (L.) Desf. (False Solomon's Seal)
Veratrum californicum Durand (Corn Lily)

Orchidaceae – Orchid Family
Corallorhiza maculata Raf. (Spotted Coral Root)
Habenaria dilatata (Pursh) Hook. var. *leucostachys* (Lindl.) (White-flowered Bog-orchid)
Habenaria sparsiflora Wats. (Sparse-flowered Bog orchid)
Listera convallarioides (Sw.) Torr. (Broad-leaved Twayblade)
Spiranthes romanzoffiana C. & S. (Ladies Tresses)

Poaceae (Gramineae) – Grass Family
Agropyron trachycaulum (Link) Malte (Slender Wheatgrass)
Agrostis diegoensis Vasey (Thin Grass)
Agrostis exarata Trin. (Spike Redtop)
Agrostis idahoensis Nash (Idaho Redtop)
Agrostis scabra Willd. (Tickle Grass)
Agrostis stolonifera L. var. *major* (Gaudin) Farwell (Redtop)
Agrostis therianaurb Hitchc. (Thurber Bentgrass)
Agrostis variabilis Rydb. (Mountain Bentgrass)
Alopecurus aequalis Sobol. (Short-awn Foxtail)
Avena fatua L. (Oat)
Bromus inermis Leyss. (Smooth Brome)
Bromus marginatus Nees. (Mountain Brome)
Bromus tectorum L. (Cheat Grass)
Calamagrostis canadensis (Michx.) Beauv. (Canadian Reedgrass)

Calamagrostis inexpansa Gray (Northern Reedgrass)
Cinna latifolia (Trev.) Griseb. (Drooping Woodreed)
Dactylis glomerata L. (Orchard Grass)
Deschampsia caespitosa (L.) Beauv. (Tufted Hairgrass)
Deschampsia danthonioides (Trin.) Munro (Annual Hairgrass)
Deschampsia elongata (Hook.) Munro (Slender Hairgrass)
Elymus glaucus Buckl. (Blue Wild Rye)
Elymus triticoides Buckl. (Beardless Wild Rye)
Festuca rubra L. (Red Fescue)
Festuca subulata Trin. (Bearded Fescue)
Festuca viridula Vasey (Greenleaf Fescue)
Glyceria elata (Nash) Hitchc. (Tall Mannagrass)
Glyceria pauciflora Presl. (Mannagrass)
Hordeum brachyantherum Nevski (Meadow Barley)
Hordeum californicum Covas & Steb. Z (California Barley)
Lolium perenne L. (Perennial Ryegrass)
Melica bulbosa Geyer (Onion Grass)
Melica fugax Bo1. (Little Onion Grass)
Melica stricta Bo1. (Rock Melic)
Muhlenbergia andina (Nutt.) Hitchc. (Foxtail Muhly)
Muhlenhergia filiformis (Thurb.) Rydb. (Slender Muhly)
Muhlenbergia richardsonis (Trin.) Rydb. (Mat Muhly)
Oryzopsis hymenoides (R. & S.) Ricker (Indian Ricegrass)
Phleum alpinum L. (Mountain Timothy)
Phleum pratense L. (Timothy)
Poa annua L. (Annual Bluegrass)
Poa bolanderi Vasey (Bolander Bluegrass)
Poa canbyi (Scribn.) Piper (Canby Bluegrass)
Poa compressa L. (Canadian Bluegrass)
Poa cusickii Vasey (Cusick Bluegrass)
Poa epilis Scribn. (Skyline Bluegrass)
Poa fendleriana (Steud.) Vasey (Mutton Grass)
Poa gracillima Vasey (Pacific Bluegrass)
Poa nevadensis Vasey (Nevada Bluegrass)
Poa nervosa (Hook.) Vasey (Wheeler Bluegrass)
Poa palustris L. (Fowl Bluegrass)
Poa pratensis L. (Kentucky Bluegrass)
Poa sandbergii Vasey (Sandberg Bluegrass)
Poa scabrella (Thurb.) Benth. (Pine Bluegrass)
Sitanion hystrix (Nutt.) J. G. Sm. (Squirrel Tail)
Stipa californica Merr. & Davy (California Needlegrass)
Stipa columbiana Macoun. (Columbia Needlegrass)
Stipa occidentalis Thurb. (Western Needlegrass)
Trisetum canescens Buckl. (Tall Trisetum)
Trisetum spicatum (L.) Richt. (Spike Trisetum)
Trisetum wolfii Vasey (Wolf's Trisetum)

Potamogetonaceae – Pondweed Family
Potamogeton foliosus Raf. (Pondweed)

Appendix 2. Mammals of the Whittell Forest and Wildlife Area. Habitat: A, aspen; DM, dry meadow; JP, Jeffrey pine forest; LP, lodgepole pine forest; MCF, mixed coniferous forest; MS, montane shrub; R, riparian; WM, wet meadow; U, ubiquitous.

Species	Habitat	Abundance
Vagrant shrew	R, WM	fairly common
Trowbridge shrew	JP, LP, MCF	fairly common
Dusky shrew	U	uncommon
Northern water shrew*		
California mole	JP, LP, MS	fairly common
Little brown myotis*		
Fringed myotis*		
Long-eared myotis*		
Yuma myotis*		
Long-legged myotis	U	fairly common
Silver-haired bat	U	common
Red bat*		
Big brown bat	U	fairly common
Hoary bat*		
Western big-eared bat*	U	fairly common
Mexican free-tailed bat*		
Black bear	U	common
Raccoon	LP, R	extirpated?
Marten	JP, MCF, LP	rare?
Shorttail weasel	U	fairly common
Longtail weasel	U	uncommon
Badger	U	uncommon
Striped skunk	U	uncommon
Coyote	U	common
Mountain lion	U	uncommon
Bobcat	U	fairly common
Mountain beaver	R, A	uncommon
Yellowbelly marmot*	JP, DM	extirpated?
California ground squirrel	JP, MS	common
Belding ground squirrel	DM	extirpated
Golden-mantled ground squirrel	JP, MS	common
Yellow pine chipmunk	JP, LP, MS, MCF	abundant
Long-eared chipmunk	JP, MS, MCF	common
Lodgepole chipmunk	MCF, JP, MS	uncommon
Western gray squirrel	JP, LP	uncommon
Douglas squirrel	LP, JP, MCF	common
Northern Flying squirrels	LP, JP, MCF	uncommon
Sierra pocket gopher	DM, LP	abundant
Great Basin pocket mouse	MS	east edge of WFWA
Beaver	R	extirpated
Western harvest mouse	R	uncommon
Deer mouse	U	common
Pinon mouse	MS	east edge of WFWA
Bushy-tailed woodrat	R, MS	uncommon
Mountain vole	R	common
Longtail vole	R	uncommon

Western jumping mouse	R	uncommon
Porcupine	U	extirpated?
Snowshoe hare*	MCF	rare?
Mountain cottontail	JP, LP, MS	fairly common
Mule deer	U	fairly common

*Recorded from the Carson Range but no recent sightings in Little Valley

Appendix 3. Birds of the Whittell Forest and Wildlife Area. Habitat: A, aspen; JP, Jeffrey pine forest; LP, lodgepole pine forest; M, meadow; MCF, mixed coniferous forest; MS, montane shrub; R, riparian; U, ubiquitous; F, flyover on migration. Status: SR, summer resident (breeding); PR, permanent resident (breeding); SV, summer visitor; WV, winter visitor; T, transient.

Species	Habitat	Status	Abundance
American white pelican	F	T	uncommon
Mallard	R	SR	fairly common
Turkey vulture	U	SR	common
Northern goshawk	JP, LP, MCF, R	PR	uncommon
Sharp-shinned hawk	U	T	fairly common
Cooper's hawk	U	SR	fairly common
Red-tailed hawk	U	PR	common
Peregrine falcon	U	SR	rare
Golden eagle	U	PR	uncommon
Osprey	U	SV	uncommon
Northern harrier	M	SV	uncommon
American kestrel	M, MS	SV	uncommon
Blue grouse	LP, MCF, JP, MS	PR	common
Mountain quail	MS, JP	SR	common
California quail	MS, R, JP	SR	common
Wild turkey	JP	PR	rare (extinct?)
Killdeer	M	T	uncommon
Common snipe	M	SR	fairly common
Spotted sandpiper	R, M	T	uncommon
California gull	F	T	uncommon
Band-tailed pigeon	JP, MCF	SR	uncommon
Mourning dove	R, JP	SR	common
Northern pygmy owl	JP, LP, MCF	PR	fairly common
Flammulated owl	MCF	SR	uncommon
Great gray owl	JP, LP, MCF	T	rare
Long-eared owl	R	T	uncommon
Saw-whet owl	JP, LP, MCF	T	common
Common poorwill	JP, MS	SR	common
Common nighthawk	F	T	uncommon
Rufous hummingbird	JP, LP, MCF, R	T	common
Calliope hummingbird	JP, LP, MCF, R, A	SR	common
Black-chinned hummingbird	MS, JP	T	rare
Belted kingfisher	R	SV	fairly common
White-headed woodpecker	JP, MCF	PR	fairly common
Lewis' woodpecker	MS, JP, LP, MCF	SV	uncommon
Northern flicker	U	PR	common
Hairy woodpecker	JP, LP, MCF	SV	common
Downy woodpecker	R	PR	common
Red-breasted sapsucker	A, JP, LP, R	PR	common
Williamson's sapsucker	MCF	PR	uncommon
Black-backed woodpecker	MS, JP, LP, MCF	PR	uncommon
Pileated woodpecker	JP, LP, MCF	PR	rare
Olive-sided flycatcher	JP, LP, MCF	SR	common
Western wood-pewee	JP, LP, MCF, A	SR	abundant

Willow flycatcher	R	SR	rare
Hammond's flycatcher	JP, LP	SR	common
Gray flycatcher	MS, R,	T	uncommon
Pacific-slope flycatcher	R, LP	T	uncommon
Dusky flycatcher	JP, LP, MCF	SR	fairly common
Barn swallow	F	T	uncommon
Tree swallow	JP, MCF	SR	uncommon
Rough-winged swallow	R, M	T	uncommon
Steller's jay	JP, LP, MCF, A, MS	PR	common
Scrub jay	JP, M	PR	uncommon
Pinyon jay	JP	SV	uncommon
Black-billed magpie	M	SV	uncommon
Clark's nutcracker	MCF, JP, LP, MS	PR	common
Common raven	U	PR	uncommon
Mountain chickadee	MCF, JP, LP, A, R	PR	abundant
Bushtit	MS, JP	PR	common
White-breasted nuthatch	JP, LP, MCF, A, R	PR	common
Red-breasted nuthatch	JP, LP, MCF	PR	common
Pygmy nuthatch	JP	PR	fairly common
Brown Creeper	JP, LP, MCF	PR	common
Dipper	R	PR	fairly common
House wren	JP, LP, MCF	SR	abundant
Rock Wren	MCF	SR	fairly common
Bewick's wren	R	PR	uncommon
American robin	U	SR	abundant
Varied thrush	JP, LP, MCF, R	T	uncommon
Hermit thrush	MCF, LP, R	SR	uncommon
Swainson's thrush	LP, R	T	rare
Mountain bluebird	M, MS	T	uncommon
Western bluebird	MCF, JP	SR	common
Townsend's solitaire	JP, MCF	SR	common
Golden-crowned kinglet	MCF	PR	uncommon
Ruby-crowned kinglet	JP, LP, MCF	SR	common
Blue-gray gnatcatcher	R, MS, JP	SR	uncommon
European starling	M	T	uncommon
Cedar waxwing	R	T	uncommon
Warbling vireo	A, R, LP	SR	common
Cassin's vireo	A, JP, MCF	SR	common
Prothonotary warbler	R	T	accidental
Orange-crowned warbler	R, MS	T	common
Virginia's warbler	R	T	rare
Nashville warbler	R, MCF, LP, JP	SR	common
Yellow-rumped warbler	JP, MCF, LP, R	SR	abundant
Black-throated gray warbler	MS, JP	T	rare
Townsend's warbler	JP	T	uncommon
Hermit warbler	JP, MCF	SR	fairly common
Yellow warbler	R, A, MS	SR	uncommon
MacGillivray's warbler	R, LP	SR	common
Wilson's warbler	R	SR	common
Common yellowthroat	R	T	rare
Red-winged blackbird	M, R, LP	SR	common
Brewer's blackbird	M, R, LP, MS	SR	common
Brown-headed cowbird	R, LP	SR	common

Bullock's oriole	R	T	uncommon
Western tanager	JP, MCF, LP	SR	common
Black-headed grosbeak	R, MS	SR	fairly common
Lazuli bunting	MS, R	T	fairly common
Evening grosbeak	MCF, JP	SR	uncommon
Cassin's finch	JP, MCF, LP	PR	common
House finch	JP	SV	rare
Pine grosbeak	MCF, A, R	SR	uncommon
Pine siskin	MCF, JP, LP	PR	common
Red crossbill	LP, MCF, JP	PR	common
Green-tailed towhee	MS, JP	SR	common
Spotted towhee	MS, JP	SR	common
Dark-eyed junco	LP, JP, MCF, R	PR	abundant
Chipping sparrow	LP, JP	SR	fairly common
Brewer's sparrow	MS	T	uncommon
White-crowned sparrow	R, MS, JP, LP, MCF	PR	common
Golden-crowned sparrow	JP, MS	WV	uncommon
Fox sparrow	MS, JP	SR	common
Song sparrow	R, LP	PR	common
Lincoln sparrow	R, LP	SR	fairly common