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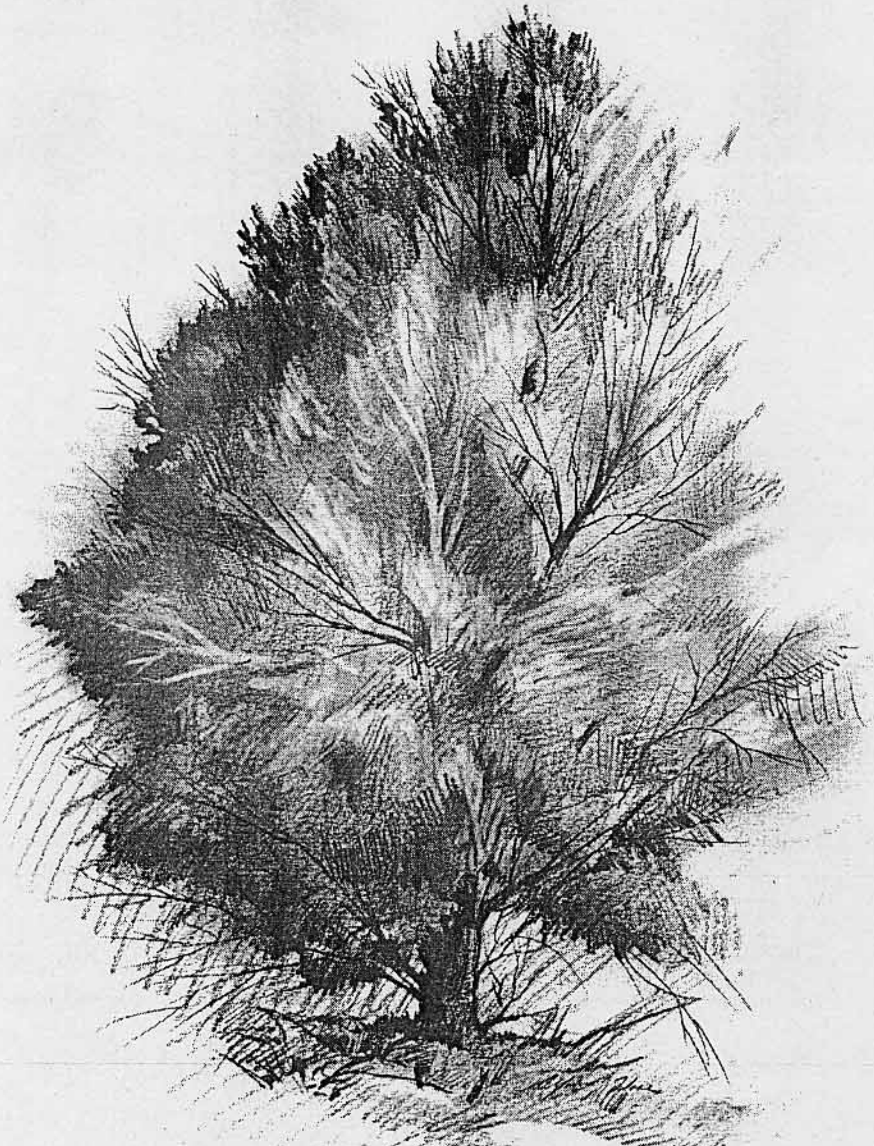

Sustaining and Restoring a Diverse Ecosystem

Harvesting Energy from 19th Century Great Basin Woodlands

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Abstract—The pinyon/juniper woodlands of the Great Basin were a vital source of structural wood and energy products for the mining industry from the 1860's to the 1930's. Pinyon and juniper were cut extensively for fuel wood and for the production of charcoal, the only available fuel or energy source for the smelters of central Nevada. Firewood and fence post for ranches were also important uses of pinyon and juniper. Deforestation by cutting, promiscuous burning continued unabated until the 1920's and 1930's, when fossil fuels, substitute types of structural wood, and fire control combined to decrease disturbance in this vegetation type.

This presentation is an updated adaptation of historical reviews first presented by Budy and Young (1979) and Young and Budy (1987). The vestiges of a once-flourishing wood products industry haunt the current managers of the pinyon-juniper woodlands. Land managers, users, and environmentalists alike suffer from a lack of historical perspective when they contend with management practices in pinyon-juniper woodlands. This is most apparent in the management of shrubs in pinyon-juniper woodlands as habitat for mule deer (*Odocoileus hemionus* subsp. *hemionus*).

The pinyon-juniper woodlands of the Great Basin are unique in how they relate to other types of vegetation. In the Rocky Mountains and the Southwest a forest of pine (often *Pinus ponderosa*) is usually located above the pinyon-juniper zone. In the central Great Basin, a mountain brush community occupies this site. The species composition of shrubs, forbs, and grasses in this community suggest a forest, but the trees are absent. In the Southwest, pinyon-juniper communities often merge with oak (*Quercus*) woodlands. Oaks are absent from central Nevada with the lower edge of the pinyon-juniper zone merging with *Artemisia* plant communities. Thus the central Great Basin was unique among nineteenth century mining areas where energy was a problem. Other portions of the west usually had some forest resources besides pinyon and juniper available for use.

The mountain crest of the highest ranges of the Great Basin support five-needled pines, of which bristlecone (*Pinus longaeva*) and limber pine (*Pinus flexilis*) are best known. Although the sparse forest were generally remote and limited in area, they were still heavily cut to supply mines with structural timbers and lumber.

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Mining in the West-Central Great Basin

The mining era in Nevada was ushered in by discovery of the silver-rich Comstock Lode in 1859 and subsequent developments during the 1860's (Elliot 1973). As the mining districts on the Comstock grew in size, the supply of fire wood seldom met demand. The pinyon and juniper in the Virginia Range were removed in an ever expanding circle. In 1864, for example, several hundred American laborers were constantly cutting and hauling firewood from nearby woodlands. Chinese laborers followed the wood cutters, pulling up the brush, stumps, and roots from overcut hills. It was a common experience for boys growing up on the Comstock to spend their after-school hours searching mine dumps for discarded wooden candle boxes to feed the family heating stove (Galloway 1947). When 6 ft of snow covered the roads during the winter of 1866-1867, a cord of wood cost from $40 to $50. An estimated 120,000 cords of firewood were used in the district in 1866 (Lord 1883). The scant supply of pinyon and juniper on the neighboring hills was rapidly exhausted, and wood cutters moved to the eastern slopes of the Sierra Nevada, some 20 miles from the mines.

Although the pine-fir forest of the eastside Sierra assured an abundant supply of timber and fuel, transportation to the mines was expensive. The construction and maintenance of mountain roads became so costly that natural waterways were used whenever possible to move logs down to the mills in the valley below Virginia City. Because of the limited number and size of waterways, water transportation was not satisfactory until the 1870's when the V-flume was developed and proven practical. Then sawmills were erected in the mountains, and cordwood and timbers were transported down the flume from the Sierra. More than 700 cords of fuel wood and 500,000 board feet of mining timbers were transported down the Carson and Tahoe Lumber Company's flume daily (DeQuille 1889). Spring floods on the Carson River also were used for transporting wood. More than 150,000 cords of wood were floated down the Carson in a typical season.

Although the adjacent Sierra slope fulfilled much of the Comstock's demand for wood products, its use of pinyon and juniper was still extensive. The Comstock is located on the edge of these woodlands in the Great Basin. Utah juniper extends north of the Comstock, but singleleaf pinyon occurs south of a line running diagonally across Nevada, from Virginia City to the Idaho-Utah-Nevada corner (Beason 1974). Mining operations along the Comstock Lode from the early 1860's until well into the present century drew upon this adjacent wood resource. As a result, more than 190,000 acres of second-growth pinyon-juniper woodland now cover Douglas, Ormsby, and southernmost Washoe Counties (Wilson 1941).

Use of wood in subsequent mining strikes and boomtowns in western Nevada and eastern California (for example, Aurora and Bodie) more or less followed the same pattern: transportation of fuelwood and timbers from the adjacent Sierra Nevada and secondary reliance on pinyon-juniper woodlands, especially for firewood.

Mining in Central Nevada

In 1862 a former Pony Express rider who was cutting wood discovered silver ore in the Toiyabe Range, 175 miles east of Virginia City. This new find, around which grew the town of Austin and the Reese River Mining District, brought the wood energy crisis into sharp focus. Central Nevada was too far removed from the Sierra Nevada for the transportation of huge quantities of fuel. The pinyon-juniper woodlands alone had to sustain the mining industry.

In contrast to the free-milling ores on the Comstock, the Reese River ores were called refractory or rebellious (Oberbillig 1967). The Reese River ores were dry crushed and roasted with salt to permit amalgamation with mercury. Although dry crushing was a terrible health hazard to the millworkers, it saved the cost of drying the crushed ore before roasting and prevented losses from oxidation of wet ores. The salt was harvested from playas in the desert valleys and often packed to the mines using camels (Young 1982).

During the 1860's, the Reese River mills used reverberatory furnaces in which the ore was heated on hearths and roasted, with the flame passing across the top of the bed of ore. These furnaces took 7 hours to roast each charge of ore, consumed salt amounting to 8 or 10 percent of the ore volume, and burned a cord of wood per ton of capacity (Rossiter 1870). There was only one source of fuel for roasting the ore, and that was the pinyon-juniper woodlands. Roughly 60 percent of the expense of milling ore was for fuelwood.

The efficiency of roasting was greatly improved by the development in 1869 of a new furnace by C. A. Stetefeldt. The principle of this furnace is that finely ground silver ore and salt are completely chloridized when they fall against a current of hot gas. The Stetefeldt furnace became the standard roasting mechanism for the central Great Basin until all amalgamation processes were replaced by the cyanide process early in the twentieth century (Oberbillig 1967).

Only one-third as much wood was required with the Stetefeldt furnace as compared to earlier furnaces, and the labor requirement was greatly reduced. The technology developed on the Reese River Mining District provided the model for next three decades.

Charcoal Production

Despite savings in wood with the new technology, the energy source became very expensive once stands of pinyon and juniper adjacent to the mills were cut. There was no water transportation available in the arid mountains, so costs were reduced by carbonizing the raw wood to charcoal before transportation to the mills.

The production of charcoal had a long history in Europe and was a part of all ancient civilizations. Industrial charcoal production, such as was practiced by the early iron smelting industry in Sweden, was a major cause of extensive deforestation. Spanish cultures had a long heritage of charcoal production from oak. Charcoal from oak was burned in California long before the gold rush. By carbonizing wood through controlled combustion, it was possible to obtain fairly high-energy-value fuel with a 60 percent savings in volume and about 80 percent savings in weight over raw cordwood. During the 1860's and 1870's, several million bushels of charcoal were produced in the northeastern United States for use in the manufacturing of iron (Hough 1878). The charcoal industry started in what became the United States with the construction of a kiln about 80 miles from Jamestown, Virginia in 1620 (Baker 1985). As the iron industry moved west to Pittsburgh, the demand for charcoal greatly increased. Charcoal iron production increased until 1880, when about 800,000 tons were produced.

Making charcoal from wood is essentially the process of partially burning the wood. The degree to which the wood is burned is controlled by regulating the amount of air admitted. Heat generated by burning the wood distills combustible vapors, which arise from wood surrounding the burning zone. The heat caused by the burning of these gases distills more gas from surrounding wood, and the zone of distillation moves progressively through the pile. Enough air is admitted to burn the gases, but not enough to burn the carbon residue, which is charcoal. If the burning process is correctly done, the result is good charcoal, relatively free from volatile and vaporous material (Anonymous 1943).

A common industry in the eastern United States during the nineteenth century was the capture of and condensation of gases released by the charcoal burning process. Before petrochemical production, all industrial important organic chemicals were obtained from wood (Baker 1985). Most of these chemicals were obtained from hardwood-distillation. Longleaf pine (*Pinus palustris*) was important for the production of pine tars and oils from which turpentine was refined. Early miners in California and Nevada did distill pine oils from native trees. The sap of digger (*Pinus sabiniana*) and Jeffrey pine (*Pinus jeffreyi*) contain a volatile, explosive chemical which caused stills to explode (Mirov and Kraebel 1939). The precious metal milling and recovery industry in the Great Basin would have required large amounts of pine tar for waterproofing the largely hydraulic milling operations, but there is no record of singleleaf pinyon being distilled for pine tar production.

Cutting singleleaf pinyon, Utah or western juniper for fuelwood is a miserable job. Mature pinyon and juniper trees seldom exceed 30 to 35 ft in height and 20 inches in diameter at the base. In addition to their small size, both species usually have poor growth form. Open grown trees are often multi-stemmed and exceedingly bushy. Both species lack natural pruning, and thus retain branches right down to the ground. These characteristics make pinyon and juniper difficult to fell and buck into cordwood. We estimate that cutting a cord of pinyon wood required at least two or three times as much labor as cutting a cord of ponderosa pine.

Pinyon logs were cut and allowed to dry before they were burned in earth-covered pits. The term charcoal pit is misleading. Although in the finished kiln the wood was completely covered with soil, the base was usually located at the soil surface. In construction of the pit, a center chimney was made, either by driving three poles into the ground and keeping them separate, or by building a triangular crib of wood in the center. The chimney was packed to part of its height with dry grass, twigs, or other loose combustible material. This material was used to start the fire. The chimney served as a support for the pile of wood and as a flue to aid the draft and carry off smoke. The charge of wood was piled around the central chimney, standing on end and leaning slightly toward the center. Top layers were put on flat, so the kiln was dome shaped.

The entire mound, except for the central opening at the top, was covered with grass and pine needles to a depth of 3 to 5 inches. This fine organic material was topped with 2 to 5 inches of clay soil; sandy soil would not provide the correct seal. Care was taken to make the soil layer as air tight as possible. Small openings were left around the bottom for draft. The size of these holes was varied or controlled by putting in or taking out soil.

Management of the burning process required considerable skill. The kiln was lit through the central chimney. After the fire was well started, the draft was reduced. Burning conditions were judged by the color of the smoke. The kiln had to be watched night and day, and wet clay was kept on hand to repair any cracks. A 100-cord pit kiln probably required from 3 weeks to a month to burn.

When it was judged that all wood in the kiln had been completely burned, all openings were closed. The cooling process required a week to 10 days for large kilns. Opening the cooled kiln was a dangerous operation, best carried out when the wind was still. Unless it was completely cold, the kiln was always in danger of igniting the charcoal during the opening process.

Utah juniper and curlleaf mountain mahogany (*Cercocarpus ledifolius*) were also converted to charcoal. These species required higher temperatures for conversion to charcoal than can be obtained with ground pits. To properly control overdrafts, beehive-shaped ovens were constructed from native stone (Grazeola 1969). Many perfectly symmetrical ovens remain today in isolated parts of Nevada as monuments to the back-breaking labor of a forgotten industry.

The yield of cordwood from pinyon-juniper woodlands can vary from less than 1 cord to more than 12 cords per acre. A charcoal pit produced from 2,000 to 3,300 bushels of charcoal from a supply of 100 cords of wood. Therefore, roughly 10 to 100 acres of woodland had to be cut for each pit. Probably the lower yielding woodlands were too sparse for their use to be economical. A yield of 300 bushels of charcoal per acre may have been a reasonable average.

Eureka, about 60 miles east of Austin, Nevada, became important in the 1870's and 1880's. From 1869 to 1863 the Eureka District produced $60,000,000 of gold and silver and 225,000 tons of lead. Smoke from roasted ores was so severe, elongated stacks were run up the canyon walls and then vertically to vent the fumes from this Pittsburgh of the West. The major milling companies were processing 750 tons of ore per day. The milling process required 25 to 35 bushels of charcoal per ton of ore. An estimated 1.25 million bushels of charcoal were consumed at Eureka in 1875 (Anonymous 1875).

The demand for charcoal was so great that deforestation became a severe problem. From our estimates of wood yield, 4,000 to 5,000 acres of woodland had to be cut annually to supply Eureka mills. By 1874 the mountain slopes around Eureka were denuded of pinyon and juniper for a radius of 20 miles. The average hauling distance from pit to smelter was 35 miles (Anonymous 1875).

Deforestation pushed shipping costs higher until the price of charcoal topped 30 cents per bushel. The standard transportation unit was 16- to 20-mule teams pulling four wagons, hitched in tandem, each loaded with 4 tons of sacked charcoal.

Eureka is a well-documented, but not isolated, example of the use of pinyon-juniper woodlands. The spread of mining brought prospectors, with little and big boomtowns, to virtually every mountain range in Nevada (Paher 1970).

In the far Northwestern Great Basin there is little evidence that western juniper (*Juniperous occidentalis*) was extensively cut during the settlement period (1870-1920) (Miller and Rose 1995). There was no large mining industry in eastern Oregon, and other wood resources were available through much of the region. It also appears the western juniper woodlands were limited in area compared to current conditions. Pre-settlement western juniper was often found on ridge-tops or on low sagebrush sites that were relatively safe from wildfires. In 1936 and 1937, during the establishment of the Squaw Butte Experimental Range near Burns, Oregon, crews traveled 40 miles to cut juniper posts to fence the range. Today, there are extensive western juniper woodlands on the experimental range. The pulse of western juniper establishment that has occurred in eastern Oregon is too recent to have provided wood resources during the early settlement period.

Miners who operated north of the pinyon-juniper distribution in the Great Basin used drastic measures to obtain energy. The Dexter Mine at Tuscarora, Nevada, used sagebrush (*Artemisia tridentata*) to fire boilers. Sagebrush was cut and delivered to the mine for $2.50 per "cord." The hoisting woks smoked like a miniature Vesuvius and the entire area was covered with ashes (Paher 1970).

In the early twentieth century, sagebrush was a major source of fuel for settlers on the Minidoka irrigation project located in south-central Idaho. It was a mark of economic achievement when a family, trying to establish an irrigated farm in the desert reclamation project, could afford to switch from collecting sagebrush to purchased juniper or lodgepole pine (*Pinus contorta*) as a source of fuelwood (Anonymous 1924).

Other Uses of Pinyon-Juniper Wood

Despite the huge demand for charcoal in mills, the use of pinyon and juniper wood in home heating and cooking may have had an even greater effect on the total woodland environment. The denuded area around Eureka, Nevada, accounted for a relatively small percentage of the pinyon-juniper woodlands in the Great Basin. The 70-mile-diameter cutting circle contained roughly 2.5 million acres, of which 0.6 million acres or 24 percent was pinyon-juniper woodlands; this equals 3.4 percent of the 17.6 million acres of this vegetation type in the Great Basin. Every isolated mine and ranch had to have wood as a source of fuel and building material. The corrals, for example, at the Walti Hot Springs ranch in central Nevada are constructed of 3,000 juniper poles. Some 50 miles of barbed wire fence is supported by juniper posts, with 260 posts per mile. The woodlands above the ranch are laced with wagon roads among the stumps left from past use. One may multiply this example by the hundreds of ranches and thousands of mining prospects to estimate the true extent of use of the pinyon-juniper woodlands.

When large ranches in the Humboldt Valley of Nevada were first fencing with barbed wire during the 1880's, they could buy redwood posts from California cheaper than juniper posts from the over-utilized woodlands of the Great Basin (Gordon 1880). Many ranchers employed Indian woodcutters to supply posts. Thirty Mile Charley was an enterprising Paiute resident of Montello, Nevada, who contracted with the giant ranches of the Utah Construction Company. His crews cut 3,000 to 4,000 posts per season (Bowman 1958).

The accelerated use of pinyon-juniper woodlands also brought promiscuous burning. David Griffiths, a trained scientific observer, reported in 1902 that every mountain range in the northern Great Basin showed evidence of recent wildfires. He attributed most of the fires in areas remote from railroads to promiscuous burning.

Sheep, cattle, and horses, Griffiths noted, heavily utilized the Great Basin ranges at the turn of the century. Domestic livestock did not eat the pinyon or juniper reproduction, but, by depleting the herbaceous understory vegetation, they favored the re-establishment of woody plants by reducing competition and changing the fuels available for wildfires.

Depleted by promiscuous hunting to near extinction, mule deer herds grew at exponential rates during the first half of the twentieth century (Clements and Young 1997). This growth in mule deer populations paralleled the growth of shrub populations, especially in former pinyon-juniper woodlands. As trees re-established and eventually grew to dominance that depleted shrub populations, many mule deer populations have crashed.

After World War I, the Great Basin gradually became dependent on fossil fuels for energy; first the cities and towns, and then, even more slowly, the rural areas. A declining rural population also helped to lessen use of pinyon-juniper woodlands.

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