THE HISTORICAL STABILITY OF NEVADA'S PINYON-JUNIPER FOREST

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ABSTRACT

The singleleaf pinyon-Utah juniper forests of Nevada have long been depicted as invasive communities that have expanded from sparse populations on rough terrain to overwhelm large areas of shrubland, reducing their forage value. This paradigm has led to deforestation programs to restore a cover condition thought by range managers to have characterized these lands at the time of settlement in the mid-19th century. We examine contemporary descriptions of the forest, mainly germane to the immense wood resources needed to support the mining and smelting industry. The early descriptions indicate that the pinyon-juniper forest was widespread, continuous over many mountain ranges throughout much of the state, and frequently dense. A comparison of lower forest border elevations reported in the 19th century with those currently mapped show no evidence of downward expansion. Three case studies of areas documented to have been deforested in the 19th century, have naturally re-forested, showing the resilience of the forest. Deforestation for restoration reasons is not justified in the absence of site-specific evidence that shrubland invasion has occurred in historic times. *Phytologia 93(3): 360-387 (December 1, 2011)*

KEY WORDS: pinyon-juniper, singleleaf pinyon, Utah juniper, woodland expansion, invasive plants, John Muir, Nevada forests, Great Basin ecology

The vestiges of a once-flourishing wood products industry haunt the current managers of the pinyon-juniper zone – J. A. Young and J. D. Budy, 1979

The pinyon-juniper forest of singleleaf pinyon *(Pinus monophylla* Torr.& Frém.) and Utah juniper *(Juniperus osteosperma* [Torr.] Little*)* is widespread in Great Basin portions of Utah and Nevada. It has been estimated at 7.6 million acres in Nevada (Miles 2011), with the vast majority on public lands. The small size and slow growth of these drought-adapted trees have long presented a utilization conundrum to the USDA Forest Service and USDI Bureau of Land Management. As a result, commodity production has stressed livestock rather than forest products.

Starting in the 1950s, fears were expressed within the managing agencies that the pinyon-juniper forest was rapidly expanding – by invading previously treeless lands and by becoming denser -- thus threatening the productivity of historical rangelands whose forage plants could not compete with the conifers. The management response was to deforest lands presumed to have been so invaded, and convert them to pasturage for cattle (USDA Forest Service 1973, 1974). Between 1960 and 1972, trees on over a third of a million acres in Utah and Nevada were uprooted by chains dragged behind bulldozers (Lanner 1981). Later plans were to deforest almost 400,000 more acres in those states (USDA Forest Service 1973, 1974). “Chaining” abated during the 1970s and 1980s, in part because benefit-cost ratios for enhanced forage production proved generally negative (Workman and Kienast 1975, Clary 1989). Further, range scientists reported that cleared areas often began to reforest naturally within 15 years (Tausch and Tueller 1977), raising questions about the permanence of deforestation (Lanner 1977, 1981).

A core issue regarding this pinyon-juniper forest, and other species combinations elsewhere in the West, has been the cause of its expansion. For several decades it has been suggested that grazing, fire exclusion, or climate change have been responsible, yet “...surprisingly little empirical or experimental evidence is available to support or refute any of these hypotheses; most interpretations are based on logical inference” (Romme et al. 2009). Nor has more than passing notice been given the impacts of forest clearing for fuel wood, charcoal manufacture, posts, ties and structural timber during the settlement and silver mining era in 19th and early 20th century Nevada, despite the magnitude of those impacts having been frequently described (Lanner 1977, 1981, Young and Budy 1979, Young and Svejcar 1999, Charlet 2008, Straka and Wynn 2008). Even the frequently cited "invasion paper" by Blackburn and Tueller (1970) makes no mention of past harvest, despite the study areas being located between and among important 19th century mining centers.

Another key issue is the magnitude of expansion. A view that has become influential in range science is that much of the pinyon-juniper forest was savanna-like – a shrubland or grassland with scattered trees – in which old trees were restricted to fireproof rocky or dissected topography (West 1988).

This led to the "logical inference" that the present area of forest has resulted from aggressively invasive behavior since settlement, more than doubling the pre-settlement area (Miller et al. 2008), and perhaps increasing it ten-fold (Miller and Tausch 2001). The first of these estimates is based on demographic studies conducted on one of the 126 Nevada mountain ranges (0.8 %) upon which singleleaf pinyon grows (Fig. 1), the forest history of which was barely considered; and a similar study in one central Utah range. The second estimate conflates all western North American woodlands, so is not discussed further. Some estimates confound expansion into unforested areas with increased density of existing forest ("infill"), so "invaded" acreages may have limited meaning (Romme et al. 2009, Weisberg et al. 2007).

Recent field and modeling studies in the Simpson Park Range of central Nevada, known to have been harvested for charcoal production, show that evidence of mining-era forest harvest and re-growth can be detected if appropriate forensic methods are employed (Ko et al. 2011). This work was facilitated by historical data that identified areas likely to have been harvested, and the location of transportation networks. In principle, such harvest evidence should be discoverable anywhere deforestation has occurred, using these techniques and realistic assumptions of stump and relic decay rates

(Reno 1994, Wessels 2010, Ko et al. 2011). Strachan (2011) has subjected even carbonized remnants and cultural remains of both juniper and pinyon to careful dendrochronological analysis, including use of local tree-ring chronologies.

OBJECTIVES

In this article we consult historical records of pinyon-juniper forest distribution and abundance in 19th century Nevada for evidence that supports or refutes the hypothesized large-scale invasion of shrublands. This task is made more difficult – and, paradoxically– made easier, by the history of land use particular to Nevada. On the one hand, the original 19th century forest was very heavily impacted by the mining boom that began in western Nevada’s Comstock Lode in 1859, and continued with interruptions throughout the state into the early 1900s. So today’s forest is significantly modified from what would have been its natural trajectory. On the other hand, the critical importance of fuel wood to the mining industry fostered an unprecedented level of documentation by agents of the State of Nevada, and the United States, of the industrial potential of pinyon and juniper fuel wood.

METHODS

For information on the distribution, occurrence and characteristics of singleleaf pinyon-Utah juniper forest in 19th century Nevada, we consulted official contemporary documents of the State of Nevada and the United States Government that resulted from explorations and on-site assessments of mining; and the writings of John Muir, Charles Sprague Sargent, E. W. De Knight, Franklin B. Hough, C. Hart Merriam and Frederick V. Coville. Data on present-day distribution of singleleaf pinyon were taken from *Nevada Conifers, A Phytogeographic Reference* (Charlet 1996). This reference was also used for the names of most mountain ranges, several of which have changed since the 19th century.

Present-day elevations of forest borders and the names of several mountain ranges were taken from topographic maps in *Nevada Atlas & Gazetteer* (DeLorme 2008). A mountain range base was identified by locating the abrupt change in spacing of contours (interval = 200 ft.) found where the steep mountain or hill slope continues on a gentler gradient into the nearly flat valley below, usually termed the pediment or bajada. This allows comparison with the elevation of the border of woodland shading (mean of two locations on east slope, and two on west slope). According to DeLorme (personal communication, customer service representative, June 2011) the DeLorme topographic maps are subjected to field testing with regard to woodland shading. Singleleaf pinyon, and by definition the pinyon-juniper forest or woodland, is almost entirely absent from the wedge-shaped area of the state north of the Humboldt and Truckee Rivers (Charlet 1996), so few relevant data were found there.

RESULTS

PINYON-JUNIPER FOREST DISTRIBUTION IN 19TH CENTURY NEVADA

Geographic Distribution

The occurrence of singleleaf pinyon- Utah juniper forests in Nevada at the time of settlement or shortly thereafter is documented in contemporary accounts at three geographic levels – that of the macro-landscape, the individual mountain range, and the Mining District. Singleleaf pinyon is most often referred to in contemporary documents as “nut pine”, in recognition of the food value of its large nut-like seeds to the Indian inhabitants of the Great Basin (Lanner 1981). Utah juniper is referred to as “cedar”, “mountain cedar’, or “juniper”. When the species occur together in Nevada, singleleaf pinyon is usually dominant or codominant (Charlet 1996).

1. Contemporary Macro-Landscape Observations

Referring broadly to Nevada’s mountains, Browne and Taylor (1867) wrote “They are covered nearly everywhere from base to summit with a growth of terebinthine (i.e. resinous) forests, consisting of a variety of pine....” Base elevation was put at 5,000 ft., summit elevation at 9,000 ft.

That same year, Stretch (1867) reported on an exploration made the spring of the preceding year in southern Nevada by Governor

Blaisdel. Along the route from Indian Springs to Pahranagat, a four to five-day trip," It will be seen that the whole of this section of the State is tolerably well supplied with wood and water."

Two years later, Stretch (1869) reported that "The nut pine, the juniper and the mountain mahogany (*Cercocarpus ledifolius* Nutt.), thinly cover portions of the mountains through the interior and western sections of the State....When it is stated that such timber is abundant, it is only meant as a temporary supply (as it) can never be abundant as the pine in the forests of the Sierras...." Stretch's apparent low appreciation of the pinyon-juniper forest resource is at variance with his frequent use of such terms as "dense", "abundant", "covered for miles", and even "inexhaustible" when describing specific locations (see below).

Reporting on his explorations of 1871, Lt. Wheeler (1872) wrote: "Piñon pine and a stunted growth of mountain cedar abound in frequent localities in Nevada".

The most detailed early observations of large scale singleleaf pinyon occurrence were those of John Muir. In the summer of 1878 the naturalist accompanied a U. S. Coast and Geodetic Survey triangulation party in a "rambling mountaineering journey of eighteen hundred miles" across and within Nevada (Badé 1924). Muir ascended the Augusta Mountains, the Desatoya Range and the Shoshone Mountains. He crossed the Reese River Valley, climbed the Toiyabe Range, and arrived in the mining center of Austin. He traveled down Big Smoky Valley, climbed the Toiyabe Range a second time as well as the Toquima Range, went south to Lone Mountain and climbed it, ascended the Hot Creek Range and traveled to the mining center of Belmont. He journeyed to another mining center, Hamilton, climbed Mt. Hamilton in the White Pine Range and visited a fourth mining center, Treasure City. His itinerary also included Ward, still another center of mining, in the Egan Range, and finally the Snake Range, which he apparently climbed. In addition, it is clear that he also climbed the Golden Gate Range, as he encountered Great Basin bristlecone pine (*P. longaeva* D. K. Bailey) there (Muir 1961). While resting later in the smelting hub of Eureka, the smoky "Pittsburgh of the West", he wrote the essay "Nevada Forests" which later appeared as Chapter 13 of *Steep Trails* (Muir 1918).

Thus, Muir had first-hand knowledge of at least eleven Nevada mountain ranges, and ascended at least ten of them. Of the singleleaf pinyon, or nut pine, he generalized: “In the number of individual trees and extent of range this curious little conifer surpasses all the others combined. Nearly every mountain in the State is planted with it, from near the base to a height of from eight thousand to nine thousand feet above the sea. Some are covered from base to summit by this one species, with only a sparse growth of juniper on the lower slopes to break the continuity of these curious woods....Tens of thousands of acres occur in one continuous belt. Indeed, the entire State seems to be pretty evenly divided into mountain ranges covered with nut pines and plains covered with sage - now a swath of pines stretching from north to south, now a swath of sage; the one black, the other gray; one severely level, the other sweeping on complacently over ridge and valley and lofty crowning dome.”

Muir saw the inroads that mining and settlement were making in these forests, and commented that “Many a square mile has already been denuded in supplying these demands, but so great is the area covered by it, no appreciable loss has as yet been sustained.”

Muir observed that “... you find the ground beneath the trees, and in the openings also, nearly naked....Here and there occurs a bunch of sage or linosyris, or a purple aster, or a tuft of dry bunch-grass”.

Following a “hurried journey “to Nevada, famed dendrologist C. S. Sargent (1879) remarked that at first the landscape seen from the new Pacific Railroad appeared almost destitute of trees. “The first impression will disappear, however, should (the traveler) penetrate further south, and ascend some of the low mountain ranges....” where “Large areas of forest-covered mountain ranges are still held by the General Government....” The railroad was routed along the Humboldt River, the northern boundary of singleleaf pinyon across much of the state.

Clearly, the extent of pinyon-juniper forest impressed travelers who encountered it, even in the southern desert regions.

2. Mountain Range Observations

Numerous records of singleleaf pinyon distribution have been reported at the mountain range level. Stretch (1867, 1869) characterized the Shoshone Mountains as having an abundance of wood, and the White Pine Range as "all quite densely covered with the usual growth of timber". He described the Toiyabe Range as originally having been in many places "covered with the nut pine and juniper", while wood was scarce in the Fish Creek Range. The Diamond Mountains were reported to have "a thrifty growth" of nut pine and mountain-mahogany. Of the Worthington Mountains he reported in 1867 the "whole range is well timbered with nut pine", but in 1869 mentioned only "a small supply of timber", the difference possibly due to heavy cutting in the interim.

Raymond (1869) described the high ridge of Mt. Irish, about five miles long and one-half to two miles wide, as well covered with nut pine and cedar.

According to White (1871) there was wood in abundance in the Schell Creek Range which featured such well-wooded mining districts as the Piermont, Nevada, McDugal, Patterson, Cooper and Fairview; as well as the Antelope Range, the Pine Grove Hills, the Snake Range and the Egan and Cortez Mountains. The Snake Range was home to the Snake, Sacramento, Pleasant Valley, Clifton, Lincoln and Shoshone Mining Districts, all of which were well supplied with pinyon. The low hills of the Ruby Mountains were covered with nut pine, juniper, and mountain-mahogany; and the hills surrounding Tem Piute Peak – the Timpahute Range – were covered with pinyon and juniper. The area 30 miles south of Clover Valley – apparently a reference to the Cherry Creek Range, perhaps including Spruce Mountain, was described by White (1871) as "rolling country principally covered by nut-pine and cedar".

Wheeler (1872) found the Humboldt Range to be "pretty well covered by cedar and nut pine", and reported that wood occurs in abundance in the "Candolara" (Candelaria) Hills. Wheeler also reported of the Silver Peak Range in Esmeralda County that its timber extended twelve to fifteen miles along the summit of the range, in a belt eight to ten miles wide, consisting of singleleaf pinyon, Utah juniper, and mountain-mahogany, which "is small but good for that country and plenty of it".

Hough (1878) quoted Mrs. E. R. Chase of Wells, NV: "The range east of the Humboldt Range is covered on its upper surface with piñon pine, and its lower part with juniper. The former supplies all the country hereabout, and the towns along the railroad, with fuel, and it is nearly all the timber in the eastern portion of Nevada. It is rapidly disappearing under the demands of the neighboring towns." Mrs. Chase was apparently referring to the Wood Hills, possibly the Pequop Mountains. The Humboldt Range referred to is now the East Humboldt Range.

Recent investigation by Ko et al. (2011) of "land-use legacies", i.e. forensic evidence of past harvesting such as stumps and charcoal oven platforms, have shown that the Simpson Park Range was the site of logging of pinyon and juniper during the mining era, though we find no mention of that in our historical references.

After transiting southern Nevada, Coville (1893) reported of singleleaf pinyon that "All along the eastern slope of the Sierra Nevada, as far northward as the expedition went, and southward to the mountains about Antelope Valley, as well as in all the higher peaks eastward to the Colorado River, the tree occurred abundantly". The Nevada desert ranges upon which it was observed by the Biological Survey of the Death Valley were the White, Grapevine, Charleston (Spring), Magruder, Pahroc, Gold, and Virgin Mountains.

Merriam (1893) traversed the same areas as Coville. He reported singleleaf pinyon to be common in Nevada in the Charleston Mountains where nut pine and cedar "abounds" in frequent localities for 50 miles, in the Pahroc Mountains, and on Gold Mountain and Mt. Magruder. Of the latter range he reported "Mount Magruder is notable for the luxuriance of the nut pine forests which clothe its higher hills and peaks, and has long been a favorite resort of the Paiute Indians, who speak of it as 'Nut Pine Mountain'....The trees often attain a height of 12 or even 15 meters (40 to 50 feet) and a diameter of half a meter (nearly 20 inches)."

The Pine Nut Range and Washoe Mountains (Virginia Range) were also reported by several observers to have been heavily wooded with pinyon-juniper forest. They will be discussed below in connection with their deforestation. Several additional ranges have been named by Carlson (1974) as the locations of Mining Districts reported in the 19th century to have harbored pinyon-juniper forests. They are the Bristol, Grant, Groom, Highland, Mountain Boy, Kinsley, Palmetto, Reveille, and Sulphur Springs Ranges and Peavine Mountain.

The mountain ranges described in the reports cited above are widely scattered across virtually all sections of the state that are within the distribution area of singleleaf pinyon (Fig. 2).

3. Contemporary Mining District Reports

Mining Districts in Nevada were areas designated by name, with defined but varying boundaries containing one to many mines. For example, in the first two quarters of 1870 there were at least 89 mines active in the White Pine District, and many inactive at the time the report was written (Raymond 1873). Districts were organized by the miners for governance in areas outside the sway of state or county law. Stretch (1867) listed 114 districts and the number swelled to 182 by the early 20th century (Tingley 1998). Nevada State Mineralogists, county assessors, and other officials compiled mining statistics largely on a district basis.

Examination of the references consulted in this study disclosed 78 districts about which comments were made on the availability of wood for use as fuel, either as cordwood or charcoal, for industrial or domestic use. Many of the districts produced refractory silver ores that required smelting or roasting, and the railroad infrastructure to deliver coal from faraway coal-fields only began to be implemented in the third decade of mining (Charlet 2008). Therefore, wood resources were critically important and were consumed in immense quantities. It was advantageous to have accessible fuel wood in close proximity to the mines and mills, and the most important wood was that of singleleaf pinyon, which made superior charcoal (Lanner 1981). Thus it was necessary to appraise the wood resources in the districts as an indicator of economic viability.

Of those 78 districts, 20 (26%) were listed in more than one reference, allowing us to evaluate the consistency of the reporting. For example, the wood resources of the Freiberg (or Freyberg) District were described by White (1871) as “nut pine sufficient for mining purposes” and by Wheeler (1872) as “Timber sufficient for fuel and building”. Of the Shoshone District in the Snake Range, Stretch (1867) reported “fuel abundant”, Raymond (1870) “well wooded”, and White (1871) “nearly the whole space described is covered with nut pine”. Multiple reports of the same district were generally similar in 18 (90%) of the 20 districts with such reports.

Districts described as having “limited”, “a small quantity”, or an absence of pinyon resources were eight in number (10%). At least four of these were on the Humboldt River (Battle Mountain) or well north of it (Independentia, Pueblo, Vicksburg) and outside the range of singleleaf pinyon.

Those in which the terms “densely wooded”, “abundant”, “plenty”, “good supply”, or “fine supply” appeared, numbered 40.

Districts in which nut pine was said to be “inexhaustible”, or the area “covered” or “well-wooded” numbered 16; and districts that had a “sufficiency” or “supply” of nut pine numbered 18. Several districts were described with more than one of these adjectives. The terms used in characterizing the pinyon resource of 32 Mining Districts by Stretch in 1867 and 1869 appear in Table 1.

Pinyon pine-bearing districts were scattered from the Snake Range on the Utah boundary in the east, to the Pine Nut Mountains facing California across the Carson Valley in the west; and from the Cortez Mountains just south of the Humboldt River in the north, to the Charleston Mountains a few miles from Las Vegas in the south. It is apparent that the majority of Mining Districts, which were distributed mainly in the mountains, benefitted from their proximity to a widely spread forest that contained significant volumes of cordwood.

Elevational Distribution

1. The Lower Forest Border

Here we contrast the elevation of the lower border of the pinyon-juniper forest as it was reported in the 19th century and by Wilson (1941), with its present-day elevation. Most reports of rapid pinyon-juniper forest spread concern expansion at the lower forest border into sagebrush steppe (Miller et al. 2008, Weisberg et al. 2007). Such spreading might occur down alluvial fans , or more generally down the gentle lower slopes or bajadas. Only a few germane 19th century observations could be found.

According to Muir (1918) the lower forest border was at the base of the mountains. Base and forest border elevations at two locations each, on the east and west slopes of three ranges that Muir climbed – the Shoshone, Toiyabe, and Toquima Ranges – are shown in Table 2.

Muir's statement that the forest border coincides with the base of the mountains holds up well for the Shoshone Mountains and the Toiyabe Range, though less precisely for the Toquima Range. However, there is no evidence of the forest border at these locations having expanded into the valleys. The placement of forest borders on the DeLorme (2008) maps reflects their elevation at a point in time, and land-use or natural events may have influenced those locations before or since. For example, trees may have invaded lower on the slopes, but were removed by chaining prior to the DeLorme mapping.

Coville (1893) reported that singleleaf pinyon grew from 5,100 ft. elevation on the west slope of the Charleston Mountains. We found the mean of lower forest border elevations on this slope near the mouths of Carpenter and Wallace Canyons and below Mount Stirling to be 5,867 ft. Coville also reported the lower pinyon-juniper forest border on the south slope of Gold Mountain to be 6,800 ft. Our analysis of the small forest area of this minor mountain finds 7,000 ft. as more typical. These observations do not indicate a downslope expansion of the forest edge.

According to Wilson (1941) the pinyon-juniper belt in the Pine Nut Mountains adjoins the sagebrush steppe on the east side at about 5,500 ft. At three locations on that slope, however, mapped elevations of the lower border have a mean of 6,000 ft. (Red and Mill Canyons and Rice Peak). Again, there is no evidence of lowering of the forest border in the approximately 72 years elapsing between observations. This is consistent with the earlier information cited above.

2. The Upper Forest Border

Pinyon-juniper forest expansion up mountain slopes has been suggested (West 1988, Weisberg et al. 2007)). On mountains higher than the historic upper limit of pinyon-juniper forest this might require replacement of ponderosa pine (*Pinus ponderosa* Douglas ex Lawson & C. Lawson) forest, limber pine *(P. flexilis* James) woodland, or mountain-mahogany woodland, depending on the location. Historic sources and current maps are of limited value in identifying such replacements.

Browne and Taylor (1867) reported pinyon-juniper forest attaining 9,000 ft, but without specifying any locations.

John Muir (Muir 1918) generalized an upper elevation of 8,000 to 9,000 ft., with the result that, “viewed comprehensively” the forest sweeps on “complacently over ridge and valley, and lofty crowning dome”. In three of the ranges that Muir climbed, as depicted on the DeLorme topographical maps (DeLorme 2008), woodland shading is continuous from summit ridges to the mountain base. These are the Shoshone Mountains from Buffalo Peak (9,036 ft.), South Shoshone Peak (10,052 ft.) and North Shoshone Peak (10, 313 ft.); the Toiyabe Range from Mahogany Mountain (10,970 ft.), French Peak (10,779 ft.) and Toiyabe Range Peak (10,960 ft.); and the Toquima Range from Little Table Mountain (9,756 ft.) and Mt. Wilson (9,205 ft.). It is not possible however to determine from the maps how much of that shading represents pinyon-juniper forest, and how much might indicate subalpine woodlands of limber pine.

Wilson (1941) described the pinyon-juniper forest of the Pine Nut Mountains and the Washoe Mountains as climbing “over the upper slopes to dominate the landscape”.

According to Charlet (personal communication, July 2011), the highest actual record of singleleaf pinyon in Nevada is from 9,990 ft. on Hayford Peak in the Sheep Range; and the uppermost known limit of the pinyon-dominated woodland is 8,766 ft. in the Snake Range.

PINYON-JUNIPER FOREST RECOVERY FROM DEFORESTATION

Deforestation proceeded rapidly after mining began in Nevada. Sargent (1879), for example, cited "the terrible destruction of forest, which follows, both on public and private domain, every new discovery of the precious metals"; and added, in 1880, that the pinyon "...will soon be exterminated, largely made into charcoal (cited in Strachan 2011)". Adding to the devastating effects of ordinary deforestation was the reported practice of pulling up roots, stumps and brush from cutover areas (Young and Budy 1979).

The extent of deforestation can only be reconstructed from fragmentary information on such imprecise parameters as amount of charcoal used in smelting, bushels of charcoal per cord of wood, cords of wood per acre; cords of wood used for home heating and cooking over the decades, and for generating steam in mining machinery; acreage cleared for home sites, mill-sites, transportation corridors, pasturage, agricultural needs, structural needs, posts for fences, corrals; number of railroad ties, cordwood used to fuel locomotives, and many other factors. Lanner (1981) very roughly estimated about 750, 000 acres were denuded to fill these needs. Young and Budy (1979) estimated that by 1878, 600,000 acres had been denuded within 35 miles of Eureka.. Charlet (2008) estimates that in 1874-1879, 1.14 million cords of fuel wood were consumed in Virginia City, the output of about 80,000 acres. He estimates that over 33 years Nevada's railroads consumed the output of 63,300 acres. Charlet (2008) concludes that "...while the pinyon-juniper forests were not wiped out, their range was significantly decreased...." He does not estimate a total acreage of deforestation. A comprehensive estimate remains elusive.

Below are some especially well-documented episodes of deforestation:

Eureka Area

According to Earl (1979) by 1878 the pinyon-juniper forest around Eureka in central Nevada had been denuded to a distance of 50 miles. A circle of this magnitude includes the Diamond, Butte, and Roberts Mountains; and the White Pine, Antelope, Pancake, Monitor, Mountain Boy, Fish Creek, Simpson Park, Sulphur Springs, and Maverick Springs Ranges. We found historical reports only for the Diamond Mountains and the White Pine Range (Stretch 1867, 1869), both of which were noted to be wooded. In addition are the recent reports by Reno (1994) on the Roberts Mountains, and by Ko et al. (2011) on the Simpson Park Range mentioned earlier.

Present-day forest cover is indicated by woodland shading for all twelve of those ranges on the DeLorme maps, from the base of the ranges well up the slopes. In addition, Charlet (1996) reports singleleaf pinyon to be “present” in the Antelope, Pancake, and Maverick Springs Ranges, and to be “abundant” in pinyon-juniper woodlands in all the others. Therefore all twelve mountain ranges within the reported potential area of deforestation around Eureka are now to some degree forested.

A dramatic report of deforestation in the Eureka area can be found in a letter of April 28, 1887 to the Secretary of the Interior and the Commissioner of the General Land Office in Washington, D. C., from Thomas Haydon, the United States District Attorney for Nevada (De Knight 1889). Haydon wished to prosecute cases of timber trespass on public land. In making his argument, he pointed out that for years hundreds, maybe thousands, of woodcutters had been “systematically engaged in cutting off into cordwood or burning into charcoal thousands of acres of timber on land belonging to the Government....In the region about Eureka ...there has probably been several hundred square miles of land covered with a growth of nut-pine timber from 8 to 10 inches in diameter to 30, and from 8 or 10 feet to 30 feet in height, and with cedar considerably less in diameter and height (that) have been swept bare, and probably one or two million cords of wood have thus been taken off of public land...." Of wood hauled by the Eureka and Palisade Narrow Gauge Railroad, Haydon writes "...four-fifths of it is not over 5 inches in diameter, and scarce one tree out of fifty is over 8 inches in diameter. The fact is, all that land was culled and cut over once, taking all trees of any size, and now they are cutting it over a second time and sweeping every young tree and bush over 2 or 3 inches in diameter." Haydon found similar conditions around Austin, White Pine, Belmont, Pioche, and "...every other large mining camp in this State...." Haydon's Eureka region information was verified by a mine superintendent and a marshal.

Haydon's unique contribution is to document the tree sizes involved in the indiscriminate cutting of second-growth forest less than two decades after mining began; and to state that cutting practices were similar in all major mining districts. This indicates that deforestation was both widespread and sustained.

Cortez Mining District

The Cortez Mining District was established in 1863 in the Cortez Mountains of north-central Nevada. Stretch (1867) characterized Mt. Tenabo, which dominates the area, as being "covered from base to thousands of feet up its side to the vein" with nut pine. About 1868 the mill updated its ore processing methods, now requiring large amounts of charcoal made from singleleaf pinyon. In his report of 1869 Stretch again referred to a "whole mountain covered with nut pine". An archaeological study made by Hattori and Thompson (1986) has utilized repeat photography and tree-ring dating of trees and stumps to synthesize a history of deforestation and recovery at this location. Their data are used here.

The original forest at Cortez extended from the bajada at about 5,770 ft. elevation to about 8,750 ft. atop Mt. Tenabo (similar to Muir's [1918] generalization). Mining and ore processing continued with some breaks until 1928. During much of that period the effects of clearcutting to fill the needs for charcoal, cordwood, and construction timber had a dramatic impact on the landscape, though some scattered mature trees survived the intensive cutting, apparently retained for reasons now unknown.

Matched photographs show a slope of Mt. Tenabo that was believed intensively logged between 1886 and 1892, taken about 1900; and again in 1983. The older photo shows an open savanna-like aspect of scattered lines of small bushy trees giving perhaps 10% ground cover. The more recent photo shows an almost 100% ground cover of dense pinyon-juniper forest. Hattori and Thompson speculate that, judging from the age of a small number of stumps on the bajada, a post-1840 expansion of the forest may have occurred, but they offer limited data.

According to Charlet (1996), singleleaf pinyon is found today in pinyon-juniper woodland in the extreme southern tip of the Cortez Mountains. The DeLorme map shows woodland shading throughout the Cortez and Mt. Tenabo area, and on a series of un-named hills extending to the southwest. The data and photographs presented by Hattori and Thompson (1986) clearly establish that the forest at Cortez described by Stretch in 1867 and 1869 was severely deforested, yet has returned to dominance.

The Pine Nut Mountains and Washoe Mountains (Virginia Range)

The Pine Nut Mountains, which form the eastern wall of Carson Valley in extreme western Nevada, were the source of huge volumes of singleleaf pinyon cordwood and charcoal from the opening of the Comstock Lode in 1859, continually, to well into the 20th century (Wilson 1941). As early as 1867, just eight years after mining on the lode began, Stretch (1867) reported that while the Pine Nut Mountains had formerly yielded a large supply of fuel, the hills were now “largely bare”. The industrialized complex of Virginia City, Silver City, Dayton, Gold Hill and other towns then turned to the great conifer forests of the Sierra Nevada, while mining and smelting in the interior Mining Districts continued to depend on local resources of singleleaf pinyon and Utah juniper for their needs.

Stretch (1867) reported a very similar situation in the Washoe Mountains, a continuation of the Pine Nut Mountains north of the Carson River. This range too was covered with pinyon-juniper forest when the Comstock Lode was discovered, but by 1867 “... they have been extirpated, and Virginia depends for its supply of wood and timber chiefly on the slope of the Sierra Nevada....”

Wilson (1941) reported on field work conducted in 1936-1939, by the Forest Survey of California and Western Nevada, in what he explicitly referred to as second-growth forest that had replaced the virgin pinyon-juniper forest. This second-growth had been exploited as it came back. The forest covered nearly 40 percent of Douglas County and continued over the upper slopes where it dominated the landscape of the Pine Nut Mountains. Those stands mostly ranged from 20 to 60 years of age, with the pinyon trees commonly 4-10 inches in diameter and 8-20 feet tall, and were yielding appreciable income from cordwood and pine nuts. Wilson (1941) inventoried more than 138,000 acres of second-growth stands in the Douglas County portion of the Pine Nut Mountains, and almost 30,000 acres in the Ormsby County (now Carson City County) portion.

According to Charlet (1996) singleleaf pinyon is dominant in extensive pinyon-juniper forests throughout the range, extending nearly to the highest summits. Woodland shading is shown throughout the range (DeLorme 2008).

These examples of pinyon-juniper forest recovery from deforestation demonstrate the reproductive vigor and resilience of this native forest type.

DISCUSSION AND CONCLUSIONS

Contemporary reports of Nevada’s 19th century pinyon-juniper forest do not support the concept of a sparse woodland restricted to refractory sites and forming open savannas.

On the contrary, the archives we consulted depict it as widespread, continuous and dense. By widespread, we cite locations of many forested mining districts. By continuous, we refer to many reports of forests spanning mountain ranges. And by dense, we point to repeated comments on the availability of fuel wood to support a major industry (Table 1); and the absence of comments on scattered-tree savannas. The observers – explorers, a naturalist, mining officials, scientists, a prosecuting attorney – were men of serious purpose. Their reports had financial significance. And all had eastern U. S. or European roots that familiarized them with dense forests.

By 1878 Muir was a seasoned observer of Sierra Nevada trees, forests, and land forms. He depicted the north-south oriented mountain ranges of central Nevada as densely covered over broad areas with pinyon-juniper forests. Despite the progression of deforestation Muir saw no imminent threat to so vast a resource. Muir's description of the ground beneath the forest is curiously similar to present-day conditions beneath forest said to be invaded shrubland.

The less detailed and specific observations of Browne and Taylor (1867) and of Wheeler (1872) do not contradict Muir's observations.

The lower borders of the forest on some of the mountains Muir climbed, appear not to have invaded valleys below. Nor have those of the southern mountains reported on by Merriam (1893) and Coville (1893).

Mining was conducted overwhelmingly in the mountains, where ore bodies are near the surface. It is unlikely that need and availability would be so frequently matched if the forest was limited in area and savanna-like in structure. Nor did any observer mention mines or mills running short of fuel.

The recovery from deforestation in the mining era, and chaining in the past few decades, suggests that efforts to remove these forests from the landscape (Miller et al.2008) will be futile. Range managers eradicating forest growth now rely on the "bullhog", a machine that grinds the trees it topples into mulch, to eliminate the problem of small surviving trees (Charlet 2008). But this overlooks the role of animal dispersers, especially the pinyon jays and Clark's nutcrackers that can be relied on to cache pinyon seeds across gaps in the fragmented pinyon-juniper forest (Chambers et al. 1999). These birds brought singleleaf pinyon into the Great Basin several thousand years ago (Lanner 1983) and there is no reason to think they will be incapable of keeping it there. In addition to the long-distance dispersal effected by these members of the family Corvidae, local dispersal of pinyon seeds by rodents will probably contribute to the filling in of existing stands (Chambers et al. 1999,Vander Wall 1997). The case studies of forest recovery in deforested areas testify to the effectiveness of the pinyon and juniper dispersers.

The lesson of recovery from deforestation is that Nevada's pinyon-juniper forest is an adapted and resilient plant community that should be managed sustainably in order to gain the many known benefits of forests. These include production of wood products and pine nuts, habitat for countless native species of animals and plants of higher and lower forms, carbon dioxide sequestration, moderation of microclimates, the windbreak effect, and protection of the soil in a semi-arid climate. It would be biologically and economically wasteful to attempt the deforestation of these areas in order to restore them to a condition "logically inferred", but not scientifically demonstrated, to have existed in the 19th century.

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LITERATURE CITED

Badé, W.F. 1924. The life and letters of John Muir. Houghton Mifflin Co., Riverside Press, Cambridge.

Blackburn, W. H. and P.T. Tueller. 1970. Pinyon and juniper invasion in black sagebrush communities in east-central Nevada. Ecology 51: 841-848.

Browne, J. R. and J. W. Taylor. 1867. Reports upon the mineral resources of the United States. Government Printing Office, Washington, D.C.

Carlson, H. S. 1974. Nevada place names. Univ. Nevada Press, Reno, NV.

Chambers, J .C., S.B. Vander Wall and E. W. Schupp. 1999. Seed and seedling ecology of piñon and juniper species in the pygmy woodlands of western North America. Botanical Review 65: 1-38.

Charlet, D. A. 1996. Atlas of Nevada Conifers, A phytogeographic reference. University of Nevada Press, Reno.

Charlet, D. A. 2008. Shah-kan-daw: Anthropogenic simplification of semi-arid vegetation structure. *in* Proc. Shrublands Under Fire. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, CO: RMRS-P-52: 5-24.

Clary, W. P. 1989. Test of RPA production coefficients and local assumptions for the pinyon-juniper ecosystem *in* central Utah. Res. Pap. INT-403. USDA Forest Service, Intermountain Research Station, Ogden, UT.

Coville, F.V. 1893. Botany of the Death Valley expedition. Contributions from the U. S. National Herbarium, Vol.4.

De Knight, E. W. 1889. James Nelson Burnes, late a Representative in Congress from Missouri. A. C. McClurg & Co., Chicago.

DeLorme. 2008. Atlas & Gazetteer (TM) of Nevada, 6th ed. DeLorme, Yarmouth, ME.

Hattori, E. M. and M. A. Thompson. 1987. Episodic, historic pinyon use and deforestation in the Cortez Mining District, Eureka County, Nevada. USDA Forest Service, Intermountain Research Station Gen. Tech. Rept. INT-215: 125-128.

Hough, F. B. 1878. Report upon forestry. Government Printing Office, Washington, D.C.

Ko, D. W., A. D. Sparrow and P. J. Weisberg. 2011. Land-use legacy of historical tree harvesting for charcoal production in a semi-arid woodland. Forest Ecology and Management 261: 1283-1292.

Lanner, R M. 1977. The eradication of pinyon-juniper woodland: has the program a legitimate purpose? Western Wildlands, Spring 1977:12-17.

Lanner, R M. 1981. The piñon pine, a natural and cultural history. Univ. of Nevada Press, Reno.

Lanner, R M. 1983. The expansion of singleleaf piñon in the Great Basin. *in* the Archaeology of Monitor Valley, 2. Gatecliff Shelter, D. H. Thomas, ed., Anthropological Papers of the American Museum of Natural History (New York) 59: 167-171.

Merriam, C. H.. 1893. Notes on the distribution of trees and shrubs in the deserts and desert ranges of southern California, southern Nevada, northwestern Arizona, and southwestern Utah, in North American Fauna No. 7, the Death Valley expedition, Part 2:338. Government Printing Office, Washington, D.C.

Miles, P. D.2011. FIA Forest data for the state of Nevada. Forest Inventory EVALIDator web-application version 4.01.01. USDA Forest Service, Northern Research Station, St. Paul, MN. http://apps.fs.fed.us/Evalidator/tmattribute.jsp

Miller, R. F. and R. J. Tausch.2001. The role of fire in juniper and pinyon woodlands: a descriptive analysis. *in* Galley, J. and Wilson, T. P., eds. Proc. of the Invasive Plant Workshop: the role of fire in the control and spread of invasive species. Tall Timbers Res. Sta. Misc. Pub. 11: 15-30.

Miller, R. F., R. J. Tausch, E. D. McArthur, D. D. Johnson, and S. C. Sanderson. 2008. Age structure and expansion of piñon-juniper woodlands: a regional perspective in the Intermountain West. USDA Forest Service, Rocky Mountain Research Station Research Report RMRS-RP-69.

Muir, J. 1918. Nevada forests, Chap. 13 in Steep Trails, W. F. Badé, ed., Houghton Mifflin, Boston.

Muir, J. 1961. Mountains of California. Garden City: Doubleday & Co. (Reprint of 1894 ed.)

Raymond, R. W. 1869. Mineral resources of the states and territories west of the Rocky Mountains. Government Printing Office, Washington, D.C.

Raymond, R. W. 1870. Statistics of mines and mining in the states and territories west of the Rocky Mountains. Government Printing Office, Washington, D.C.

Raymond, R. W. 1872. Statistics of mines and mining in the states and territories west of the Rocky Mountains. Government Printing Office, Washington, D.C.

Raymond, R. W. 1873. Silver and Gold: an account of the metallurgical industry of the United States. J. B. Ford and Co., New York.

Reno, R. L. 1994. The Charcoal industry in the Roberts Mountains, Eureka County, Nevada.. Archaeological Research Services, Inc., Virginia City, Nevada.

Romme, W. H., C. D. Allen, J. D. Bailey, W. L. Baker, B. T. Bestelmeyer, P.M. Brown, K. S. Eisenhart, M. L. Floyd, D. W. Huffman, B. F. Jacobs, R. F. Miller, E. H. Muldavin, T. W. Swetnam, R. J. Tausch, and P. J. Weisberg. 2009. Historical and modern disturbance regimes, stand structures, and landscape dynamics in piñon-juniper vegetation of the western United States. Rangeland Ecology and Management 62: 203-222.

Sargent, C. S. 1879. The forests of central Nevada, with some remarks on those of the adjacent regions. Amer. J. Science and Arts, third series, Art. 53, 417-426.

Strachan, S.. 2011. Dendrochronological dating of historic charcoal oven platforms in the Great Basin, North America. M. S. Thesis, University of Nevada, Reno.

Straka, T. J. and R. H. Wynn. 2008. History on the road: charcoal and Nevada's early mining industry. Forest History Today, Fall 2008: 63-66.

Stretch, R. H. 1867. Annual Report of the State Mineralogist of the State of Nevada for 1866. Joseph E. Eckley, State Printer Carson City.

Stretch, R. H. 1869. Report of the state mineralogist of Nevada for the years 1867 and 1868. Henry R. Mighels, state printer. Carson City.

Tausch, R. J. and P.T. Tueller. 1977. Plant succession following chaining of pinyon-juniper woodlands in eastern Nevada. Journal of Range Management 30: 44-49.

Tingley, J. V. 1998. Mining districts of Nevada. Nevada Bureau of Mines and Geology Report 47, 2d ed.

USDA Forest Service. 1973. Pinyon-juniper chaining programs on National Forest lands in the state of Utah. Final environmental impact statement. Intermountain Region, Ogden, UT.

USDA Forest Service. 1974. Pinyon-juniper chaining programs on National Forest lands in the state of Nevada. Final environmental impact statement. Intermountain Region, Ogden, UT.

Vander Wall, S. B. 1997. Dispersal of singleleaf piñon pine (*Pinus monophylla)* by seed-caching rodents. Journal of Mammalogy 78: 181-191.

Weisberg, P. J., E. Lingua, and R. B. Pillai. 2007. Spatial patterns of pinyon-juniper woodland expansion in central Nevada. Rangeland Ecol. Management 60: 115-124.

Wessels, T.. 2010. Forest forensics. Countryman Press, Woodstock, VT.

West, N. E. 1988. Intermountain deserts, shrub steppes, and woodlands, p. 210-230 *in* M. G. Barbour and W. D. Billings, (eds.) North American Terrestrial Vegetation. Cambridge Univ. Press, New York.

Wheeler, G. M. 1872. Preliminary report concerning explorations and surveys principally in Nevada and Arizona. Government Printing Office, Washington, D. C.

White, A. F. 1871. Report of the mineralogist of the state of Nevada for the Years 1869 and 1870. Charles L. Perkins, state printer, Carson City.

Wilson, R. C. 1941. Vegetation types and forest conditions of Douglas, Ormsby and Southwestern Washoe Counties, Nevada. Forest Survey Release No. 2, Calif. Forest and Range Experiment Station, Berkeley.

Workman, J. P. and C. R. Kienast. 1975. Pinyon-juniper manipulation: some socio-economic considerations. *in* The Pinyon-Juniper Ecosystem, a Symposium, G. F. Gifford and F. E. Busby, eds. Utah State University and Utah Agricultural Experiment Station, 163-176. Logan UT

Young, J. A. and J. D. Budy.1979. Historical use of Nevada's pinyon-juniper woodlands. Journal of Forest History 23:112-121.

Young, J. A. and T. J. Svejcar. 1999. Harvesting energy from 19th century Great Basin woodland, p. 47-50 *in* Monsen, Stephen B. and Richard Stevens, compilers. Proceedings: ecology and management of pinyon-juniper communities within the interior West, RMRS-P-9, USDA Forest Service, Rocky Mountain Research Station. Ogden, UT

Table 1.Characterization of the singleleaf pinyon (*Pinus monophylla*) resource at Nevada Mining Districts as described by the Nevada State Mineralogist (Stretch 1867, 1869).

Pinyon resource	Mining District
Scarce, hardly any	American, San Antonio
Limited amount, small quantity	Battle Mountain, Echo
Abundant, good supply, fine supply	Blind Springs, Buckeye, Esmeralda, Eureka, Great Basin, Highland, Montgomery, North Twin River, Osceola, Pahranagat, Peavine, Red Mountain, Reveille, Roberts, Santa Rosa, Shoshone, Union
Well wooded or timbered, dense or thick growth, large quantities, large areas covered	Cortez, Palmyra, Robinson, Springfield, The Jackson, Wilson's, Worthington
Inexhaustible	Mammoth

Table 2.Mean elevations at the mountain base and lower forest border at four locations of three ranges said by Muir (1918) to have pinyon-juniper forest belts descending to the mountain base. Mountain base defined as upper limit of bajada or pediment.

Range	Locations	Mean base elevation, feet	Mean forest border elev.
Shoshone	Cole, Mitchell, Mission, Buffalo Canyons	7,000	6,950
Toiyabe	Crooked, New York, Dry Canyons; Last Chance Creek	6,450	6,525
Toquima	Sam's, Mill, Willow Canyons; Manhattan Gulch	6,600	7,100

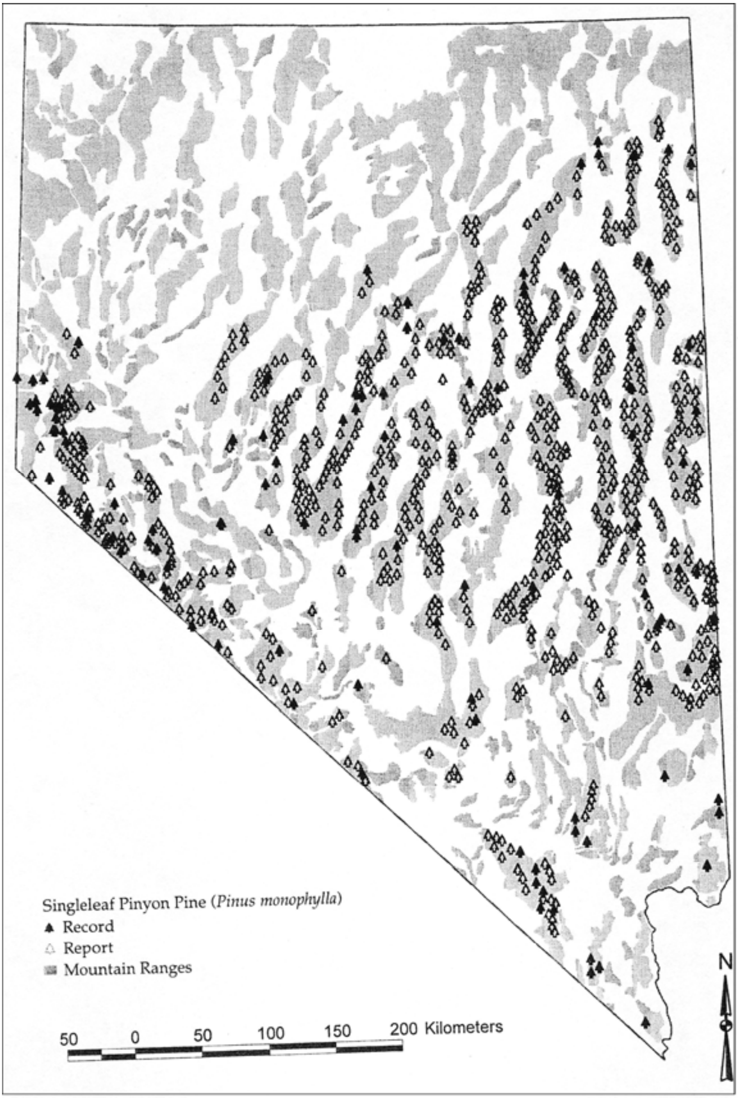

Figure 1. Present-day distribution of singleleaf pinyon in Nevada. From Charlet (1996) by permission (see Acknowledgements).

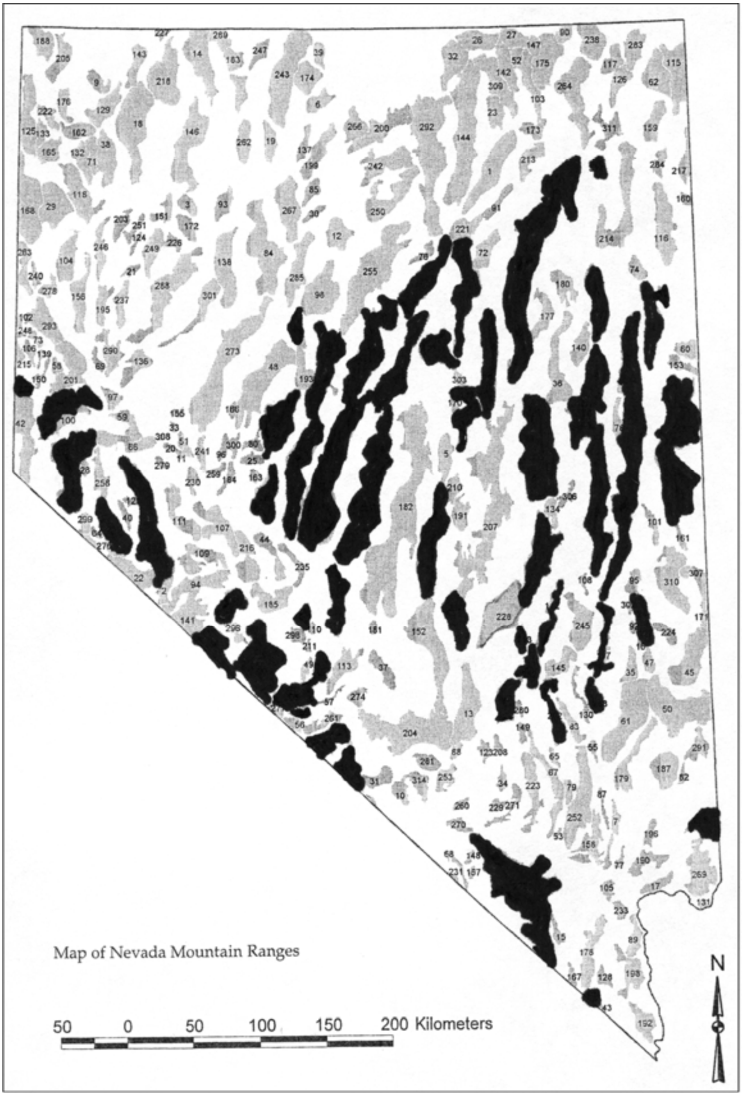

Figure 2. Nevada mountain ranges said to have major cover of pinyon pine in the 19th century. See text for individual reports. From Charlet (1996) by permission (see Acknowledgements).

Figure 3. Singleleaf pinyon-Utah juniper forest near Austin, Nevada.