Late 19th Century Human Impacts on the Woodlands and Forests of Southeastern Arizona’s Sky Islands

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Introduction
Since the late 1980s, a major public controversy has brewed over the University of Arizona’s construction of astrophysical observatories on Emerald Peak (10,471 feet) in the Graham (Pinaleño) Mountains of southeastern Arizona (Figure 1). The controversy centers on the clearing of a small patch of rare spruce-fir forest that preservationists consider an essential habitat for the endangered Mount Graham red squirrel, and it has led to an examination of conservation issues not only in the Grahams but in the other desert mountain “sky islands” that make up the basin and range physiographic province of southeastern Arizona. The metaphor, “sky islands,” was coined by Weldon Heald (1967), a popular Arizona writer and naturalist.

The biological and social issues connected with the controversy are paraphrased in Istock and Hoffman’s Storm over a Mountain Island: Conservation Biology and the Mt. Graham Affair (1995). However, only one contributor to this volume, Paul S. Martin, touched on a significant perspective unexplored in the controversy: that much, if not most, of the present-day vegetation structure of sky islands in southeastern Arizona is an artifact of long-standing human disturbance. At the turn of the 20th century the Grahams were full of livestock and the woodlands and forests were being cut for fuelwood and sawtimber. In fact, “sky islands,” was coined by Weldon Heald (1967), a popular Arizona writer and naturalist.

A great deal of cutting has been done (referring to the Grahams). In fact, it may be said that at one time or another, sawmills have been located in every accessible canyon, and at present there is very little good timber below 7,500 feet that can be reached easily. One hundred thousand feet of lumber at Jacobsen’s mill has been confiscated by the General Land Office, and will be sold at auction in a few days. These mills of course, like many others, have operated illegally for years; since they have been shut down the local price of timber is $40 per thousand where it was formerly $25.

From 1890 to 1946 and from 1962 to 1972, more than 63 million board feet (MMFB) of sawtimber were removed from the 38,000 acres of ponderosa pine and mixed-conifer forests in the Grahams. This amount does not include the timber cut between 1869, the year the first sawmill was established there, and 1890, or that cut between 1947 and 1961, or after 1972 (John Turner, Coronado National Forest, letter to author, Nov. 1987). A Coronado National Forest Service map shows that large areas were once logged around Mt. Graham between Grandview and Heliograph peaks. In other words, logging, fuelwood cutting, grazing, and fire exclusion have long affected the ecology of the woodlands and forests of the Grahams.

To understand the dynamics of montane vegetation in southeastern Arizona and its ability to recover from human disturbance, ecologists must examine the historical land uses of these ranges. Four of the major land uses that have affected Arizona’s sky islands since the advent of major Anglo-American settlement in 1870: grazing, wildfire exclusion, fuelwood cutting, and logging, are examined here.

Setting
Southeastern Arizona’s sky islands include all of the mountain ranges high enough to have woodlands and/or forests south of the Gila River and east of the Baboquivari Mountains (McLaughlin 1994:60) (Figure 1). This region is dry basin and range country. It is characterized by a series of isolated, northwest-southeast trending fault-block mountain ranges or “islands” rising above broad, intervening valleys or “seas” of alluvial fill covered by grassland and desert scrub. The lowest elevations are near Florence on the Gila River (1,490 feet); the highest are in the Graham (Pinaleño) and Chiricahua mountains (Mt. Graham at 10,720 feet and Chiricahua Peak at 9,796 feet). Of the sky islands only the Grahams, Chiricahuas, Santa Catalinas, Santa Ritas, and Huachucas exceed 9,000 feet in elevation. Considerable portions of the upland valleys east of the Santa Cruz River exceed 4,000 feet in elevation.

The climate is semiarid; average annual precipitation ranges from 9 to 25 inches, and on some of the highest peaks precipitation may exceed 35 inches. Winter and summer rains are interrupted by spring and fall aridity (Sellers and Hill 1974). At the lowest elevations, average July temperatures are near 90° F and average January temperatures are about 50° F; at the highest elevations, average July temperatures are about 65° F and average January temperatures are about 35° F (Ibid.).

Southeastern Arizona’s vegetation is extremely diverse (1,940 native and 166 nonnative species) (McLaughlin...
1994:65), and includes most of Arizona's principal life zones. These life zones, mostly stratified according to altitude, include from the lowest to highest elevations, desert scrub (Sonoran desert scrub and Chihuahuan desert scrub), grassland (semidesert and plains grasslands), Madrean evergreen woodland (a combination of oak savanna, oak woodland, oak-pinyon-juniper woodland, pine-oak woodland and interior chaparral), ponderosa pine forest, mixed-conifer forest, and at the highest elevations (only on the summits of the Graham Mountains) small patches of spruce-fir forest. The two largest areas of ponderosa pine and mixed-conifer forests are found in the Grahams (38,000 acres) and the Chiricahuas (34,000 acres) (Ron Senn, Coronado National Forest, letter to the author, Feb. 1997). Most of the evergreen woodlands and all of the ponderosa pine and mixed-conifer forests of the sky islands are within the Coronado National Forest; large areas of evergreen woodland are also found outside the national forest in the Baboquivari, Sierrita, and Dos Cabezas mountains.

**Madrean Evergreen Woodland**

The Madrean evergreen woodland covers approximately 20 percent of southeastern Arizona, mostly at elevations between 4,000 and 7,000 feet (Brown and Lowe 1980). Dominated largely by oak woodland, oak savanna, and oak-pinyon-juniper woodland, tree composition and density change with elevation and, to a lesser degree, with latitude. At lower elevations, the evergreen woodland is open; at higher elevations, particularly in wetter environs, it can be dense. Emory oak (Quercus emoryi), Arizona white oak (Q. arizonica), and Mexican blue oak (Q. oblongifolia) are among the most frequently found of the twelve common oaks in the evergreen woodland (McPherson 1992:24).

Scattered among the oaks are alligator juniper (Juniperus deppeana), one-seed juniper (Juniperus monosperma), Mexican pinyon (Pinus cembroides), and border pinyon (P. discolor), and at the lowest elevations mesquite (Prosopis spp.). At higher elevations the evergreen woodland grades into pine-oak woodland, where such pines as Apache pine (Pinus engelmannii) and Chihuahua pine (P. leiophylla) are found along with Gambel oak (Quercus gambelii). The evergreen woodland’s understory of shrubby species at higher elevations is progressively replaced at lower elevations by grasses. Also, patches of interior chaparral are scattered about, usually on thin or calcareous soils. Most species of oak seem to have different resistances to fire, but all resprout following top removal (Ibid.:29-30).

**Ponderosa Pine and Mixed-Conifer Forests**

Ponderosa pine (Pinus ponderosa) and mixed conifer generally occupy elevations above 7000 feet in the Santa Rita, Santa Catalina, Huachuca, Rincon, Chiricahua, Graham, Santa Teresa, Winchester, and Galiuro mountains. Pine-
General Land Law Revision Act of 1891 called for setting public domain for mining and domestic purposes,” the New Mexico in 1880 to “fell and remove timber from the Although Congress authorized the citizens of Arizona and Hutchinson 1985). Most fuelwood was cut from ever- ing and cooking fuel needs of the new inhabitants (Bahre 1991:36); and (4) the boom in cattle ranching. Sub- juration of the Apaches and completion of the railroad, in particular, facilitated rapid expansion of mining and ranching in the sky islands. By 1879, according to the Annual Report of the Governor of Arizona (U.S. Congress, House, 1879), all of southeastern Arizona had been prospected and mining operations were being conducted in most major mountain ranges. By 1882, large-scale copper mining activities were reported at Helvetia, Benson, Russelville, Bisbee, Clifton-Morenci, Globe, Silver Bell, and Mammoth (Arizona Daily Star Nov. 12, 1882). At that time, wood was used to fuel the steam engines associated with mining; it also met all of the heating and cooking fuel needs of the new inhabitants (Bahre and Hutchinson 1985). Most fuelwood was cut from ever- green woodlands, and before 1880 sawmills in the ponderosa pine and mixed-conifer forests of the sky islands sup- plied all of the lumber for southeastern Arizona’s settlements. By the mid-1880s, cattle, sheep, goats, and horses grazed on the sky islands’ open rangelands. Although Congress authorized the citizens of Arizona and New Mexico in 1880 to “fell and remove timber from the public domain for mining and domestic purposes,” the General Land Law Revision Act of 1891 called for setting aside forest reserves to conserve range and forest resources (Baker et al. 1988:1). In 1902, the first forest reserves in southeastern Arizona were established in the Santa Rita, Chiricahua, Santa Catalina, and Graham mountains (Ibid.). Subsequently, reserves were established in nearly all major sky islands. In 1905, the forest reserves were transferred from the Department of the Interior’s General Land Office (GLO) to the Department of Agriculture’s Forest Service (Ibid.). The Forest Service, charged with maintaining the permanence of the resources in the reserves, continued to provide for their use by agricultural, lumbering, mining, and livestock interests directly dependent on the public lands. In 1907, forest reserves were renamed national forests; in 1917, all of southeastern Arizona’s national forests, except for those in the Grahams, Santa Teresas, Galiuros, and Winchesters (then part of the Crook National Forest), were consolidated as the Coronado National Forest. In 1953, sky islands previously part of the Crook National Forest were added to the Coronado National Forest. Beginning in 1905, the Forest Service attempted to curtail free use of forage resources in the national forests and in- stituted fire suppression to protect timber and fuelwood resources. Grazing fees were collected and attempts were made to control the number of livestock on forest lands, but little of the national forest was fenced before the mid-1930s (Cooperrider and Hussey 1924). In 1934, the Taylor Grazing Act was enacted to prevent overgrazing and to stabilize the livestock industry depen- dent on public rangelands (Voigt 1976). The Forest Ser- vice, the Grazing Service (established by the Department of Interior in 1934 and merged in 1946 with the General Land Office to form the Bureau of Land Management) and a host of other federal and state agencies charged with range and watershed protection introduced changes in the montane woodlands and forests to improve range, protect tim- ber, and manage the watershed that have influenced the landscapes seen today.

Livestock Grazing Few areas in the sky islands, have escaped the impact of livestock, but we know little about the role of cattle or other livestock in the evolution of the evergreen woodlands and ponderosa pine and mixed-conifer forests of southeastern Arizona. Before 1934, most of Arizona’s public domain was open range, and large numbers of cattle, horses, sheep, and goats were found in all of the sky islands wherever there was sufficient water; even after the national forests were established (Bahre 1991:109-123). Large-scale cattle ranching began in southeastern Arizona in the early 1870s. There is evidence that Spanish and Mexican land grants near the present international boundary had cattle, horses, and sheep in the 1820s and 1830s,
but it is unlikely that cattle numbers were very large, considering the lack of developed water resources for cattle before the 1870s, the small amount of rangeland near perennial water supplies, the paucity and isolated nature of the Spanish and Mexican settlements, the control of most of southeastern Arizona by the Apaches, and the onset of Apache depredations shortly after Mexican land grants for cattle ranching were established in the mid-1820s (Wagoner 1952). Even in 1804, only 3,500 cattle, 2,600 sheep, and 1,200 horses were reported at Tucson, then the largest Spanish settlement in Arizona with a population of 1,015; at Tubac, the only other major settlement had no more than 1,000 cattle and 5,000 sheep (McCarty 1976).

Stocking of the rangelands occurred so rapidly in the 1870s and early 1880s that by 1884 every running stream and permanent spring had been claimed and adjacent ranges stocked with cattle (Cameron 1896). Sheep were also important in southeastern Arizona and according to census reports actually outnumbered cattle in 1879. Between 1880 and the early 1890s, thousands of sheep were reported in the sky islands (Bahre 1991:117). Goats were also significant in certain ranges (Cooperrider and Hussey 1924; Hadley et al. 1992).

In 1891, cattle numbers in southeastern Arizona reached nearly 400,000 (Hendrickson and Minckley 1984), more than twice the number grazing the rangelands today. The influence of these cattle numbers on the range was captured by J.W. Toumey (1891:2), a botanist at the Arizona Agricultural Experiment Station in Tucson: “There are valleys (in southeastern Arizona) over which one can ride for several miles without finding mature grasses sufficient for herbarium specimens without searching under bushes or in similar places.” Toumey (1901:126) also noted that livestock made the forest floors in some of the sky islands “as bare and compact as a road bed.”

The years 1891 and 1892 were almost devoid of summer rains, and in the first months of 1893, the combined effects of drought and overgrazing led to the death of an estimated 50 to 75 percent of the livestock in southeastern Arizona (Cameron 1896). Summer rains in July 1893 saved the cattle industry from complete ruin, but overstocking and overgrazing continued. During the next seven years, only 1898 received more than average rainfall. After October 1898, drought persisted until December 1904, with tremendous loss of livestock and continued degradation of the range (Bahre and Shelton 1996) (Figure 2).

In early 1901, David Griffiths (1901:9), then chief botanist in charge of grass and forage investigations for the Arizona Agricultural Experiment Station, observed that southeastern Arizona’s rangelands were more degraded than any others he had seen in the western United States. In June 1901, Griffiths transferred from the Experiment Station to the USDA Bureau of Plant Industry in Tucson, where as part of his employment, he inspected range conditions throughout Arizona. In 1902 and 1903, he traveled throughout the Territory, photographing degraded range conditions and dead livestock. His pictures show hundreds of square miles of rangeland denuded of cover; grasses grazed to the ground; hills covered with cattle trails (terrasettes); rampant erosion; oaks and other trees with browse lines; dead cattle and horses littering the ground near springs and water holes; and cattle bones stacked by railroad stations awaiting shipment to fertilizer plants.

A.F. Potter, a special agent for the GLO who recommended the establishment of the Santa Rita Forest Reserve in 1902, reported:

Previous to the drought of 1891 and 1892, this range (the Santa Rita Mountains) carried fully 25,000 head of cattle and horses and 5,000 sheep . . . During the winter the cattle appear to hang along the lower line of the snow and subsist mostly by browsing the oak brush, cercocarpus, and a variety of shrubs. The entire mountain section is available to cattle and they have bed grounds in the saddles of the highest peaks, and pass back and forth at will from one canyon to another. The mountain furnishes no barrier whatever to livestock drifting from one part of the range to another (Potter 1902:18-19).

Several reports similar to Potter’s describe the overgrazed conditions of the sky islands before forest reserves were established. For example, Arthur Noon, one of the first rangers in the Huachuca Forest Reserve, noted that the many cattle trails served as good firebreaks (Winn n.d.).

In 1924, the first major range appraisal of the Coronado National Forest noted that the forest lands in many areas were overgrazed and had been so since the mid-1880s (Cooperrider and Hussey 1924). After passage of the Taylor Grazing Act, the federal government, to reduce overstocking of the public domain, bought cattle for immediate slaughter; in some cases, where the condition of the cattle was too poor for shipment, they were herded together and killed on the range (Wagoner 1952:59-60). In some instances, feral mustangs and burros were shot to control their numbers.

Livestock grazing has undoubtedly played a major role in the evolution of the evergreen woodlands and ponderosa pine and mixed-conifer forests of southeastern Arizona’s sky islands, mainly in regional fire ecology. Overgrazing removed grasses so important to spreading the surface fires that once frequently burned the woodlands and forests and kept them clear of undergrowth. According to Aldo Leopold...
(1924: 9-10), a Forest Service regional supervisor in south-central Arizona at the turn of the century, overgrazing was practiced by forest administrators to reduce fire hazards and to promote tree growth. Overgrazing, in conjunction with fire suppression policies, caused both the number of fires and the area burned to decline dramatically after Anglo-American settlement (Pyne 1984). In fact, the increase of mesquite, juniper, and other woody xerophytes since the 1890s may be a result of (1) reduced frequency and intensity of wildfires in the rangelands because of overgrazing; (2) a decline in natural perennial grasses, which, when healthy and dense, can reduce woody tree seedling establishment; (3) increased dissemination by livestock of scarified mesquite seed; and (4) hoof damage to ground cover and soil compaction by livestock, resulting in reduced moisture in the upper layers of soil, which hinders grass establishment and growth.

Ironically, grazing and range management programs, with the possible exception of fire suppression, have had a major detrimental effect on the woodlands and forests of the sky islands. The rangelands have been managed for cattle for so long that their pregrazing condition is unknown. Grazing since the 1870s has led to soil erosion, destruction of the plants most palatable to livestock, changes in woodland and forest fire ecology, the spread of nonnative plants, and a steady increase in the density of certain woody plants and shrubs. In addition, grazing may adversely affect oak seedling recruitment and riparian community stability (McPherson 1992:30).

Wildfire
Before the 1890s, wildfires were common in southeastern Arizona wherever there was sufficient fuel. In fact, the sky islands have among the highest incidences of lightning fires in the United States (Komarek 1968; Schroeder and Buck 1970); 73 percent of all fires since 1959 in the Coronado National Forest were started by lightning (John Turner, Coronado National Forest, letter to the author, Nov. 1987). The lightning fire season begins in late April, peaks in June, and runs into October. The zone of maximum lightning fire occurrence in the sky islands appears to be above 6,000 feet in elevation. Our understanding of the significant role of wildfire in the evolution of the sky island forests and woodlands with a pine component is due largely to the tree-ring research of scientists at the University of Arizona (Swetnam and Baisan 1996). Unfortunately, reliable data on evergreen woodland fire history are unavailable, because most of the evergreen woodland tree species are not (yet) useful for accurate tree-ring analysis as oak growth rings are indistinct, and in some cases they are not annual. Furthermore, because of numerous false rings (in-
extra-annual latewood bands), no junipers in southeastern Arizona have been reliably dated. Recent studies, however, of fire-scar patterns at the oak woodland and pine forest ecotone in the Chiricahua and Huachuca mountains have documented fire frequencies of at least one fire per decade (Kaib et al. 1996; Danzer et al. 1996).

The significance of wildfires in the evergreen woodlands and coniferous forests of southeastern Arizona is attested to by (1) the abundance of fire scars in the tree-ring records; (2) rapid postfire recovery in the evergreen woodlands and forests; (3) historic records of wildfires and burning by Amerindians; and (4) the high incidence of lightning ignitions during the summer (Bahre 1985).

When Anglo-American settlers arrived, the pattern of fires in the sky island forests and woodlands changed from widespread surface fires to infrequent, widespread, intense crown fires. Consequently, the structure and, in some cases, the composition of the vegetation changed. A good description of the ponderosa pine and mixed-conifer forests of the sky islands before Forest Service management is found in the following statements by S.J. Holsinger (1901), a special agent for the GLO, who spent 14 days in the high elevations of the Santa Catalina Mountains with a crew of men extinguishing a major surface fire in May 1900:

The forest is practically in a virgin condition with a single exception it has never been invaded by the lumberman, and its only real enemy has been forest fires . . . only the frequent fires which sweep these mountains prevent the entire central mountain region from being densely forested. The areas exposed to the direct rays of the sun are not only covered with timber but a heavy growth of bunch grass, which readily carries fire through the forest. These fires destroy the young pines and do much damage to the mature timber . . . The numerous canyons which cross the forested district would facilitate the establishment of an effective system of fire breaks, and under proper forest regulations and patrol by forest officers forest fires would be unknown.

The Amerindians, especially the Apaches, set wildfires both before and after Anglo settlement. The Indians burned the vegetation of the region by fire drives in hunting, during warfare, and with abandoned campfires, mescal roasting fires, and smoke signals. Given their land uses and their attitudes towards fire, the Indians were surely more prone to ignite wildfires than were the 19th century Anglo-American settlers who advocated fire suppression. In any event, given the high incidence of lightning fires, reliably documented by modern data, the addition of ignitions by Indi-
est peaks . . . The entire western slope of the mountains has been burned over, and the fires are now working over and around the eastern side, making at night a strange and beautiful spectacle. (Weekly Arizonian [Tubac] June 2, 1859)

For the last month the country north, south and east of Tucson has been in a constant blaze. The grasses on the mesas, mountains and in the valleys, have been eaten up by the flames; during the last two days the fire has traveled over the Santa Catarina (Catalina) mountains and is burning now miles beyond. It has climbed almost to the summit of the Santa Rita, after devouring most of the pastures below, and bids fair to continue its course until the grass of the whole country has been licked up in flames. (Arizona Star June 23, 1877)

For the past two weeks fires have been burning on the Santa Catalina, Santa Rita, Pajarito and Oro Blanco mountains; during that time over 100 square miles have been burned over, destroying not only all grass but also all the trees and timber in the burned districts. The grass alone destroyed is an important item, but the value of the timber it is impossible to compute. (Tucson Daily Record June 4, 1880)

Fuelwood Cutting

Fuelwood, scarce in the predominantly desert scrub and semidesert grassland vegetation of southeastern Arizona, has been historically the primary source of fuel. Few people realize how much fuelwood was cut between the late 1870s and 1940s for mining operations and for domestic heating and cooking. While mining operations largely ceased using fuelwood after 1900, 44 percent of the occupied dwellings in Arizona still used fuelwood for heating and cooking as late as 1940 (U.S. Bureau of Census 1943:110-114). Fuelwood consumption declined in southeastern Arizona after 1940, but since 1973 demand for residential fuelwood has risen dramatically because of escalating petroleum costs.

According to the record, fuelwood cutting once had a major impact on the riparian forests, mesquite thickets, and evergreen woodlands near most of southeastern Arizona's major cities and mining centers. At Bisbee, the stripping of the oaks from nearby hills led to flooding in 1882 (Bisbee Review Aug 8, 1923). In 1882, fuelwood had become so scarce in southeastern Arizona that the Arizona Daily Star for 1 March 1882 reported:

The fuel question is one of the most important to the mining industry. The wood supply, as a matter of course, is fast decreasing . . . The Epitaph says: There is soon to be a change in the fuel used at
our mines and mills (Tombstone) . . . At the present rate of consumption, if continued as the staple fuel, (wood) would become an exceeding dear commodity. As it is, that supplied to the mines comes mostly from the eastern slopes of the Dragoons, from twelve to fifteen miles distant, and costs $12 per cord.

Except for the English and Colorado coke used in the blast furnaces, wood was the major fuel of the mines in southeastern Arizona until the late 1890s. Wood was burned under the boilers of the steam engines at virtually every step in mining: to run stamps, pumps, hoists, ore crushers, dryers, amalgamation pans, settlers, and converters; to roast ores; and retort amalgam. Wood fueled every steam engine in the area, from those running trains to those making ice, and it also met all heating and cooking needs. In addition, miners and ranchers cut trees to make fenceposts, favoring juniper, mesquite and desert willow (oak decays too rapidly); to make wood corrals; to kiln firebricks, especially willow and cottonwood; and to feed livestock the leaves of willow and the bark of cottonwood (Arizona Daily Star Oct. 24, 1880; Bahre and Hutchinson 1985:179).

Charcoal, made mostly from mesquite and oak, was also used throughout southeastern Arizona for a variety of tasks, from blowing in smelting furnaces to heating laundry irons. Before the late 1870s, charcoal was widely used in the old Mexican blast furnaces largely for copper smelting; after 1880, the widely used water-jacketed blast furnaces employed charcoal only to ignite coke. In some instances, coke had to be freighted long distances from rail stations. Most of the early mines in southeastern Arizona relied on animal power for hoisting and crushing ores and, although stamp mills powered by wood-burning steam engines first appeared in Arizona in the late 1860s, not until 10 years later did steam power become dominant (Bahre 1984:103-104).

Besides Tombstone and Bisbee, there were at least 30 other mining centers in southeastern Arizona. Smelters were constructed at these centers as well as at Tucson, Lochiel, Hereford, Patagonia, Nogales, and Benson (Bahre 1991). In addition, fuelwood for the Globe, Clifton-Morenci, and Silver King operations also came from the sky island woodlands of southeastern Arizona.

For the most part, the mining industry used mesquite, oak, pinyon, juniper, and some shrubs for fuel. Of these, oak and mesquite have the highest caloric values, but the extra labor needed for splitting and seasoning them sometimes offset their better quality. In general, the mines demanded seasoned wood six inches or more in diameter. However, where fuel was scarce, even the smallest trees near towns and mining settlements were cut. The Mexicans were well known for digging up mesquite roots for fuelwood. For example, at Morenci in 1890, it was reported: “Firewood had disappeared from above the ground on the hills around town, but the resourceful Mexican was still supplying his individual needs by digging for it” (Barr 1940:6). Juniper, oak, and mesquite were the primary heating and cooking fuels; also used were pine and some shrubs.

Local contractors, employing Mexican woodcutters, supplied most of the fuelwood. From all available records, there must have been many woodcutters and woodcutters’ camps, especially in the evergreen woodlands and mesquite thickets near the major towns and mining camps. Most contemporary writers took fuelwood cutting for granted, however, because they said little about it. One exception was the Tombstone Daily Nugget for 5 February 1882, which asked the citizens not to forget the woodcutters’ importance to the economic survival of the city:

Elsewhere we print what we consider authentic information as to a raid made on Friday by Indians (Apaches) in the Dragoon Mountains. Few of our people appreciate the amount of work done in the wood camps along the base of the mountain, the number of men who are exposed to danger should the raids continue, and how necessary for our mines that these men should be protected.

Although total fuelwood consumption for mining peaked during the 1890s, some mines continued to use fuelwood long after 1900. After 1890, however, most fuelwood was cut for domestic heating and cooking.

The site-specific effects of historic fuelwood cutting on the evergreen woodlands of southeastern Arizona’s sky islands, is exemplified by events that took place in the mining town of Tombstone and its “woodshed” an area within a 25 mile radius of the settlement that has served as the source for most of Tombstone’s fuelwood since the late 1870s (Bahre and Hutchinson 1985). The Tombstone woodshed covers about 2000 square miles, most of which is desert scrub. Evergreen woodland covers only about 15 percent of the woodshed.

Tombstone, established in 1878, was one of several major mining centers in southeastern Arizona that relied heavily on fuelwood. During the Tombstone silver bonanza (1879-1886), at least 50 different mines, 12 steam hoists, and 150 stamps were operating in Tombstone and its mill sites along the San Pedro River (Blake 1902:16; Spude 1979:12). Fuelwood for the boilers of engines that powered mine equipment and for domestic heating and cooking was cut from the mesquite thickets along the San Pedro River and Babocomari Creek and from the evergreen woodlands of the Huachuca and Whetstone mountains to the west and the Dragoon Mountains to the east.

Coronado National Forest researchers have calculated the following average cordages per acre for the evergreen wood-
lands in the Tombstone woodshed: 3.07 cords in the Huachuca Mountains, 3.68 cords in the Dragoon Mountains, and 3.65 cords in the Whetstone mountains (Ron Senn, Coronado National Forest, letter to author, Feb. 1997). These cordage figures are similar to those for the other sky islands. According to these figures, the average volume of oak and juniper in the Tombstone woodshed is about 3.5 cords per acre, or about 672,000 cords total. Not included in these figures, however, is the considerable volume of mesquite, mostly on non-forest lands, the total cordage of which may exceed that of oak and juniper. Annual growth rates or rates of accumulation on merchantable boles are estimated at one percent.

Bahre and Hutchinson (1985:186) estimated that at least 443,000 cords of fuelwood were removed from the evergreen woodlands, mesquite thickets, and riparian forests of the Tombstone woodshed for both mine fuel and domestic heating and cooking between 1878 and 1940. This figure, however, does not include the fuelwood cut from the woodshed for other mining centers in southeastern Arizona, such as Bisbee and Pearce, for domestic heating and cooking for the towns and cities other than Tombstone and its mill towns before 1890, for mining processes other than milling, or for the bulk of the fuelwood cut since 1940, especially for residential fireplaces in Tucson and other cities. Most likely, the total amount cut was twice this figure. In other words, the amount of fuelwood consumed between 1878 and 1940 alone was more than the total cordage reported by the Forest Service for the evergreen woodlands of the Tombstone woodshed.

The consumption of fuelwood by other mining centers in southeastern Arizona was as great as in Tombstone. For example, Barr (1940:6) observed that the fuelwood consumed by the Morenci copper mine represented about 10 percent of the total cost of operation and that in 1885 between 300 and 500 cords were used every month. The Copper Queen at Bisbee burned 3,554 cords under its boilers in 1887 (Bisbee Review Aug. 8, 1923). The Arizona Weekly Enterprise for 17 March 1888 reported that annual consumption of fuelwood at the Silver King (Figure 3), just north of Superior was 10,798 cords, enough cordwood stacked four feet high in four foot lengths to stretch a little more than 16 miles.

Fuelwood cutting must have substantially affected the Tombstone woodshed in the early 1880s, because the federal government frequently warned land claimants that it was illegal to cut wood on unpatented land claims other than to clear land for cultivation or for their own fuel needs (Bahre 1991:151-152). For example, the Arizona Daily Star for 23 April 1884 reported:

> There is considerable feeling... over the arrest of woodcutters... The reason why is, simply because the people who are

Bahre and Hutchinson (1985:184-186), who measured the incidence of cutting on the trees of the evergreen woodlands of the Tombstone woodshed, found that few oaks had been killed by cutting, especially if they had been pollarded, and that 43 percent of the trees showed clear signs of having been cut. Moreover, they noted that cut oaks have nearly three times more stems than oaks that showed no signs of cutting. They concluded that more oaks were cut than their data indicate, because many cut stems had rotted off and the cambium had grown over old wounds, obliterating any sign of cutting. They also concluded that because of woodcutting there appear to be fewer large oaks and junipers today. Juniper does not have the BTU content of oak and mesquite, but it is an excellent fuel. Some observers have doubted the impact of historical woodcutting on juniper because of the paucity of old stumps, but the dead stumps were often used for fuel.

Although woodcutting has probably affected structural changes in the evergreen woodlands of southeastern Arizona's sky islands, there is little evidence that it decreased the areal extent of woodlands. The woodlands, in particular, have remained stable, most likely because the oaks were pollarded by woodcutters (Phillips 1912:13, 15). This finding opposes a widely held notion that woodcutters commonly destroyed the woodlands around old mines, an idea that may have originated from the fact that large areas of pinyon-juniper woodland in Nevada and New Mexico were eradicated because woodcutters did not pollard the junipers, and pinyon rarely tolerates cutting (Young and Budy 1979). Today, volume of fuelwood in the evergreen woodlands of the sky islands is probably greater than at any time since 1870, because of fire suppression and Forest Service control of fuelwood cutting and grazing. Based on current Forest Service cordage and regrowth figures, demand for fuelwood from the evergreen woodlands of the sky islands since 1870 has probably equaled or exceeded the amounts available.

Logging

Although nearly all sky island forests have been logged, historic records indicate significant logging occurred only in the Graham, Chiricahua, Huachuca, Santa Rita, and Santa Catalina mountains. Of the many researchers who have studied the ecology of the ponderosa pine and mixed-conifer forests, only a few have noted the occurrence of 19th century logging and none has discussed the ecological impact (Bahre 1991:166-167). A.F. Potter's 1902 map
of the Chiricahuas is the only published map showing the extent of logging in any of the sky islands before the first forest reserves were established in southeastern Arizona (Bahre 1995). Nearly 30 percent of the ponderosa pine and mixed-conifer forest in the Chiricahuas had been logged by eleven different sawmill operations before 1902.

The first sky island extensively logged was the Santa Ritas, where yellow pine and Douglas fir were cut (largely in Sawmill and Madera canyons) to supply mine timbers (mainly stulls) and lumber for Tubac, Tucson, and other nearby settlements (Matheny 1975). In fact, the first sawmill in southeastern Arizona was established in the Santa Ritas in 1857. Other sawmills were first established in the Grahams in 1869, in the Santa Catalinas in 1873, in the Huachucas in 1878, and in the Chiricahuas in 1879 (Bahre 1991). Amerindians, Spaniards, and Mexicans undoubtedly cut logs from sky island forests before the Gadsden Purchase in 1854, but the amounts were probably insignificant.

The 19th-century newspapers of Tucson, Florence, Tombstone, and Bisbee contain scores of references to sawmills and logging in the sky islands, but they shed little light on the amounts of sawtimber cut or on ecological impact. They do indicate that historic logging operations were larger and more widespread than commonly believed. Here are typical newspaper accounts of logging in extensively harvested ranges.

<table>
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<th><strong>Huachuca Mountains</strong></th>
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<td>January 1879 . . . mill started up at Saw Mill Canyon (east side of Huachucas) after exhausting timber in that vicinity, moved to the top of the mountains, 8,000 feet altitude . . . The mill had a capacity of 10,000 feet per day, and was kept constantly running without intermission . . . (Weekly Nugget June 10, 1880)</td>
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<td>Turner and Campbell’s Saw Mill . . . one mile above Turnerville (east side of the Huachucas in Ramsey Canyon) commenced cutting lumber on the 10th of May and has turned out since that time over 90,000 feet . . . it is estimated that the lumber capacity of the canyon will be 4,000,000 feet . . . the Huachuca Saw Mill is situated high up on the northern side of McCloskey Canyon. It was built in December 1878 . . . the capacity of the mill is from 8,000 to 10,000 feet a day. Since commencing work, 1,750,000 feet of lumber have been turned on the market, and it is estimated . . . 3,500,000 feet more are available. (Tombstone Weekly Epitaph June 12, 1880)</td>
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Figure 3. Woodyard at the Silver King Mine (near Superior, Arizona) ca 1881. Note the mine stulls in the foreground. Courtesy of the Arizona Historical Society.
Graham Mountains

... the new road leads to a dense growth of timber composed of white and sugar pine, red and white fir; sufficient not only to supply the wants of this post (Camp Grant) for all time to come; it may be said to be inexhaustible; ... trees of any and all sizes can be obtained, some measuring as much as five feet through and from fifty to sixty feet in length clear of knots. The timbered part of the summit (Mt. Graham) is from one to three miles in length ...

(Santa Catalina Mountains)

We noticed some excellent saw logs brought from the San (sic) Catalina pinery by Mr. Leon and others. James Lee also has the first installment of 20,000 feet he is hauling in ...

(Santa Rita Mountains)

The saw mill of Preston and Heslip in the Santa Rita Mountains is running constantly sawing logs cut in Saw Mill Cañon.

(Chiricahua Mountains)

Chiricahua Saw mill – this mill, property of Phillip Morse and Co., has now been running nine months, and during that time over 1,000,000 feet of lumber has been shipped, most of which has been consumed in Tombstone and adjacent mills. The mill is now turning out 50,000 feet per week.

After the Southern Pacific Railroad arrived in Tucson in 1880, lumber was imported from California, Oregon, and Washington, but many miners preferred local wood for mine timber and laggins in wet ground (Tombstone Prospector Oct. 19, 1889; Arizona Weekly Enterprise Apr. 5, 1890) and until the 1910s, some mines continued to rely on local sawtimber, particularly from the Santa Catalina, Graham, and Chiricahua mountains.

Cutting timber on public lands in the early days was illegal, but the laws were rarely enforced (Baker et al. 1988: 77). The Copper Queen at Bisbee, in particular, depended on sawtimber from the Chiricahuas in its mining operations until the 1890s (Bisbee Review Aug. 8, 1923) and the Ross Sawmill from which the Copper Queen purchased its timbers was frequently cited for illegal cutting on public lands. For example, the Arizona Weekly Star for 12 November 1885 reported:

Timber Depredations ... Parties from the Chiricahua Mountains say there is a large amount of timber being cut on government land in the mountains about fifty miles from Bisbee. If this is so, this is work for the U.S. timber agents. It is said the pine timber is being literally cleared off the government land, and if the depredations continue at the present rate, there will not be a stick left on that side of the mountain.

The impact of 19th century logging is unknown. We may safely assume, however, that clear-cutting would have led to changes in the structure of the forests, with ensuing young growth stands and possibly less diversity in both animal and plant species. Clear-cutting may also have increased decomposition, nitrification, runoff, and erosion.

According to Coronado National Forest Records, 455 thousand board feet (MBF) of sawtimber were removed from the sky islands in 1987, an insignificant amount, compared with 19th century harvests or with the 7,208 MBF removed in 1980. All of the sawtimber harvested since 1971 has come from the Graham and Santa Catalina mountains (John Turner, Coronado National Forest, letter to the author, Nov. 1987). Logging waned in the other mountain ranges after 1900, and no major harvests have taken place in the Graham or Santa Catalina mountains for a decade or more.

Approximately 23 million board feet (MMBF) were removed from the Graham Mountains between 1890 and 1946 and 40 MMBF between 1962 and 1972 (Ibid.). The harvest between 1947 and 1961 was not tabulated. The total harvest of 63 MMBF amounts to clear-cutting about 10,200 acres or 16 square miles of ponderosa pine under present conditions, or about 27 percent of the 38,000 acres of ponderosa pine and mixed-conifer forest in the range (Figure 4). This figure is based on Alexander’s (1974:26) estimate that ponderosa pine stands in Arizona average about 6.2 MBF per acre. Some fully stocked stands on good sites, however, are capable of yields of 25 to 35 MBF per acre. Yields from virgin stands of big trees when these forests were first logged could have been much greater; therefore
the area cut to reach a total harvest of 63 MMBF was probably smaller than 10,000 acres. If the forests had been selectively cut, rather than clearcut the area logged may have been much greater. However, this harvest of 63 MMBF in the Grahams does not include the harvest between 1869 and 1890, 1947 and 1961, and after 1972.

During the 1980s, the annual harvest for the Santa Catalina Mountains was 230 MBF and for the Grahams 225 MBF. These figures have now declined because forest resources are being preserved for recreation and wildlife, and the harvest is now relegated to occasional salvage logging, removing diseased and insect-infested trees, or clearing for roads, camping areas, and skiing courses.

Conclusion
That the woodlands and forests of southeastern Arizona's sky islands have undergone change since 1870 is evident in the Land Office surveyors' field notes, repeat ground and aerial photography, permanent plot studies, old maps, 19th century newspaper accounts, Forest Service records, and the historical diaries and reminiscences of the first forest rangers (Bahre 1991).

Although the density of oaks and understory shrubs has markedly increased within the Coronado National Forest since 1900, little or no change has occurred in the areal extent of the evergreen woodlands, except in the few places where the trees have been cleared. Comments by early observers suggest that much of the lower-elevation evergreen woodland was open with a dense grass understory before Anglo settlement (Leopold 1924). Fires, set by lightning or by Indians, are usually identified as "disturbances" that kept the woody understory in check and maintained the open nature of the woodlands. With Anglo-American settlement fire exclusion allowed brush and scrubby trees to increase. Although different species of oaks have distinct sensitivities to fire, nearly all oaks, especially evergreen oaks, resprout vigorously from the root crown and below-ground bud zone after a fire.

Increases in the density of oaks and woody shrubs on the Coronado National Forest are thought to have resulted from fire suppression and tighter controls over grazing and fuelwood cutting. While overgrazing has led to more brush growth by lessening the occurrence of wildfire, it may have caused a decline in oak regeneration. For example, the browsing of young oak seedlings and the consumption of acorns by livestock are often cited as thwarting oak regeneration.
Historic fuelwood cutting rarely killed oaks, especially evergreen oaks, but its ecological impact has largely been ignored. This is surprising, because there is no doubt that (1) wildfires in the evergreen woodlands have diminished since Anglo settlement, (2) livestock have heavily grazed the woodlands since the mid-1800s, and (3) local woodlands supplied immense amounts of fuelwood for 19th century mining operations, as well as for domestic cooking and heating for most of southeastern Arizona’s homes before the 1940s.

The directional changes in the evergreen woodlands of the sky islands are continuous clearing of native plant cover due to expanding settlement, largely in those woodlands not included in the public domain; invasion of nonnative plants; and an increase in oak, pinyon and juniper in protected areas.

The ponderosa pine and mixed-conifer forests of southeastern Arizona’s sky islands have been "protected" by the national forest system since the Santa Rita, Mt. Graham, Santa Catalina, and Chiricahua forest reserves were established in 1902. While most of these forests continue to be grazed, exploitation since the 1930s has not been as ruthless or as destructive as it was in the late 19th and early 20th centuries. At that time, stock of cattle, sheep, horses, and goats was uncontrolled, and large areas of forest were either selectively cut and/or clear-cut for fuelwood, fenceposts, shakes, and sawtimber in spite of laws against indiscriminate woodcutting and logging on the public domain.

Since the advent of major Anglo-American settlement, wildfire exclusion, logging, grazing, fuelwood cutting, mining, the construction of transportation corridors, and Forest Service management of these activities have had a major effect on the ecology and age-structure of the ponderosa pine and mixed-conifer forests of southeastern Arizona. Historical writings and dendrochronological data clearly indicate that fire has always been a major ecological force in southeastern Arizona’s ponderosa pine and mixed-conifer forests and that fewer fires occurred in those forests after major Anglo-American settlement (Swetnam and Baisan 1996:15). Frequent, low-to-moderate intensity surface fires before Anglo-American settlement, started by lightning or humans, thinned stands, eliminated young pines and thickets, and kept the ponderosa pine forests open and parklike with an understory of bunch grasses, herbs, and shrubs (Cooper 1960; Biswell 1972). In addition, patches of mineral soil laid bare by wildfire provided favorable conditions for the growth of shade-intolerant ponderosa pine seedlings (Wright and Bailey 1982). The exclusion of fire, however, has led to dense thickets, even-aged stands, forest stagnation, and less frequent, more intense, large crown fires.

That logging once led to clear-cutting is evident in the historic record. For example, not only was most of the “good timber” in the Huachuca and Santa Rita Mountains cut out before 1900, but large areas of the Chiricahua and Graham mountains were clear-cut for mine timbers and construction materials in the 1880s and 1890s (Kellogg 1902b). The major directional changes in the forests since 1900 appear to be fewer large trees; more tree production, especially of less fire-resistant species, and denser thickets; less grass; less frequent though more intense fires, especially crown fires; desiccation and invasion of mountain meadows; the spread of nonnative plants; and clearing for transportation rights-of-way, recreational facilities, and mines.

None of the sky island evergreen woodlands and forests were pristine before they were set aside as forest reserves and national forests. By 1900 nearly all had been affected to some degree or another by mining, logging, fuelwood cutting, and grazing. At present, we have little idea what these woodlands and forests would be like had they not been logged or grazed, had the fire regimes not been manipulated, or had Forest Service management not occurred.

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