# CHANGED SOUTHWEST FORESTS: RESOURCE EFFECTS AND MANAGENENT REMEDIES

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## SUMMARY

Over 150 years of occupancy by northern Europeans has markedly changed vegetative conditions in the Southwest. Less fire due to grazing and fire suppression triggered a shift to forests with very high tree densities, which in turn contributed to destructive forest tires. Options to deal with these changes include prescribed fire, thinning and timber harvest to mimic natural disturbances and conditions. However, there are barriers to implementing these activities on a scale large enough to have a significant benefit.

**KEY WORDS**: Change forests, resource effects, forest managemente.

## LOS EFECTOS EN EL RECURSO Y EL MANEJO RECOMENDADO PARA LOS BOSQUES DEL SURESTE AFECTADOS POR LA COLONIZACIÓN.

## RESUMEN

Más de 150 años de ocupación por los europeos cambio marcadamente los bosques del suroeste. Las prácticas de reducció del fuego debido al pastoreo y supresión dieron lugar a bosque con alta denisdad, lo que dio lugar también a grandes incendios forestales más destructivos, las opciones que pueden recomendarse para contrarrestar los cambios producidos incluyen las quemas prescritas, los aclareos y los aprovechamientos maderables que semejen los disturbios naturales. Sin embargo, existen barreras para implementar estas actividades a escala suficiente para obtener beneficios significativos.

**PALABRAS CLAVE:** Efectos de la colonización, manejo forestal.

## INTRODUCTION

In this paper, 1 discuss Southwest forests around the turn of the century, discuss how they looked before then, and then show changes in recent decades. I portray how these vegetative changes affect resource values and propose some actions to avoid future negative consequences.

## THE PAST

Thousands of years of human occupation preceded the first accounts, paintings, and photographs of Southwest (SW) landscapes. We can only guess what the earliest occupants saw or thought of their landscape. We know that prehistoric people altered vegetative composition through farming and burning. The view through time’s fuzzy lens clears as we near the present.

In the late 19th and early 20th century, visitors to Southwestern forests gave us our first indication of how these forests looked then, primarily from their written observations. Although there were exceptions, most descriptions portray, especially in ponderosa pine (*Pinus ponderosa*) forests, conditions that are much more open than what we see today (Whipple, 1856, U.S. Geological Survey, 1904, Cooper, 1960). A few pictures are available from this era, and they generally show the same thing. Groups of similarly sized trees with little understory but considerable grass beneath seem to have been the most common condition.

Fires burned frequently (2 to 10 years) at low intensity in lower elevations and less frequently but with moderate intensity at higher elevations (Swetnam and Baisan, 1996). Lightning is common in the Southwest, and Native Americans also contributed to fire frequency. Escaped

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domestic fires occurred as did intentional burning, although burning by Native Americans has not bcen documented in the SW to the degree it has further north (Swetnam and Baisan, 1996).

In 1910, Woolsey and also Lang and Stewart gave us the first quantified inventories. Neither inventory was Southwest-wide, and they do not give us a picture of conditions on a same- acreage, statistically sound basis. Nevertheless, they covered several areas and included a large number of plots, so they paint the best quantified picture available today of early 20th-century conditions. They agree with a) early photographs, b) early descriptions mentioned above, c) what a forester or ecologist would expect to find given knowledge of fire regimes, and d) what studies of stumps and other factors indicate was present (Covington and Moore, 1994a).

Table 1 shows trees per acre by diameter class from Woolsey's 1910 inventory. The table compares his figures with those from U'SDA - Forest Service inventories made in 1962 and again in 1985/87. Woolsey's inventory was from plots taken in typical stands on three National Forests in Arizona. The other two inventories were based on a plot-grid that covered all of Region-3: both Arizona and New Mexico. The information is grouped by 3-inch diameter classes.

**TABLE 1. Trees per acre, by diameter class, from Southwest inventories.**

| | | Trees per acre | | |
|---|---|---|---|---|
| **3-INCH DBH CLASS** | **ACTUAL DBH-RANGE** | **1985/87 R3-INV** | **1962 R3-INV** | **AVG 3-AZNF** |
| 6 | 4.6 – 7.5 | 68.0 | 45.0 | 6.3 |
| 9 | 7.6 – 10.5 | 36.1 | 21.8 | 3.2 |
| 12 | 10.6 – 13.5 | 18.1 | 11.1 | 2.5 |
| 15 | 13.6 – 16.5 | 8.8 | 6.6 | 2.2 |
| 18 | 16.6 – 19.5 | 4.5 | 4.0 | 2.0 |
| 21 | 19.6 – 22.5 | 2.3 | * | 1.8 |
| 24 | 22.6 – 25.5 | 1.3 | * | 1.4 |
| 27 | 25.6 – 28.5 | 0.6 | * | 0.7 |
| 30 | 28.6+ | 0.4 | 0.6 | 0.8 |
| | TOTAL: | 140.1 | 89.1 | 20.9 |

### Table Notes

R3 inventory figures are for conifers only.

Specific numbers for diameter classes marked with an "*" are not available: the 1962 inventory grouped these into a single category.

1910 data is from Woolsey, and was taken on the Coconino, Tusayan, and Prescott Forests

Woolsey's data were recently converted to basal area (BA) and show that average conditions in 1910 in ponderosa pine forests ranged from BA 22.9 square feet per acre (Tusayan Forest) to 25.4 (Prescott Forest) to 37.9 on the Coconino Forest. Other plots were taken in the best stands that could be found on several forests around Arizona and New Mexico and the average is a BA of 82.0 (Woolsey data converted to BA by the Forest Service). These are all well below today's densities, which are mostly above BA 100 per acre and often up to and even greater than 200 (Forest Service data).

## POST-EUROPEAN SETTLEMENT CHANGES

A reduction in ecosystem fire occurred by the 1880's or before and about the same time that livestock grazing levels increased substantially. By 1890, cattle numbers were about 1.5 million head in Arizona and New Mexico (Baker et al, 1988). Grazing by domestic livestock removed grasses that had previously carried cool ground fires. This coincided with good moisture in the first few decades of the 20th century, which led to forests with far more trees than before. Without such moisture, grazing and other fire suppression would not have led to the overstocking. This is shown in the Chuska Mountains on the Navajo Reservation where extensive grazing by sheep and goats started in the 1820's, and fires declined. However, forest regeneration did not start until after 1900 as it did in the rest of the Region (Pyne, 1996).

Other factors contributed to reduced fine fuels and, therefore, reduction of fire frequency as the 19th century ended and the 20th began (Pyne, 1996). Loggers began removing mature trees. Bark beetles, fungi, and dwarf mistletoe infested the thickets that, in the absence of grass and fire, sprang up profusely. Severe droughts further reduced light fuels. Roads built by settlers, fixed landownership patterns, reservation of public lands, and establishment of professional forestry also contributed. In combination, the result was suppression of low-intensity fire. Through succession, this encouraged fuel arrays that promote intense fires. These fuel loads are an environmental debt, like toxic dumps. They will take decades of determined action to clean up, and that only if society has the resolve and the money (Pyne, 1996).

The decline in fire frequency was observed in virtually all Southwestern fire scar studies (Weaver, 1951; Dieterich, 1980; Swetnam, 1983 & 1990; Allen, 1989; and Savage and Swetnam, 1991). Exclusion of fire eventually results in elimination (or serious reduction) of ponderosa pine, aspen, and other forest species characteristic of frequent fire regimes. More than anywhere else, this transition can clearly be seen occurring in national parks and wildernesses, and in other areas that have never been logged (Sampson *et al***,** 1993).

Meadows also declined in area as they were invaded by aspen and conifers. This was quantified by Allen (1989, p. 260). He states, “Overall, in the southeast portion of the Jemez Mountains open montane grassland area decreased 55% from 554 ha. in 1935 to 250 ha. in 1981.” Comparison of aerial photos for other areas and local knowledge corroborate this statement.

## SOUTHWEST FORESTS TODAY

Change is still occurring. From 1962 to 1985187, the mixed-conifer forest type increased by 1,040,000 acres, or 81 percent. Ponderosa pine decreased slightly in acreage, and aspen decreased by 46 percent (Johnson, 1994). These changes may have some major impacts on resource values.

Table-1 illustrates the change in forest conditions from 1910, when the first inventories were done, compared to conditions found in the 1985/87 inventories. There has been a substantial increase in total numbers of trees in diameter classes up to 15-inches dbh and also a smaller increase in the 18- and 21-inch classes. In the 24- and 27-inch diameter classes, numbers of trees stayed about the same in 1985187 as in 1910, and in the class over 30-inches there has been a decline over time. However, the 30-inch-plus class has never been a large percentage of the total ecosystem. In 1910, this class comprised less than one tree per acre (Woolsey, 1910).

## WHAT APPENS NEXT?

You might logically ask the question, “who cares if there are more trees?” After all, trees are beautiful, provide wildlife habitat, and protect the soil. In the Southwest, managing for higher tree densities is unrealistic over the long term. From the resource manager’s perspective higher densities should he seen as infeasible. From the firefighters standpoint, they should be seen as dangerous (Williams, 1996).

There is growing concern among natural resource professionals that disruption of natural fire regimes, increase in tree numbers, and increases in landscape homogeneity are a far greater threat to biological diversity and ecosystem sustainability than is generally realized (Caraher *et al*, 1992- Kaufmann *et al.,* 1992- Everett *et al.,*1993- Mutch *et al*., 1993; Covington and Moore, 1994b; Pyne, 1996). Unless concerted actions are taken to reverse ongoing ecosystem degradation, prospects look grim for the quality of life—not only for the region’s forest and woodland ecosystems, but also for the human populations that rely on these resources (Covington *et al***,** 1994).

Many changes occur as our forests grow more dense. First, the character of forest tires change. They now hum less frequently, but are high-intensity, stand-replacing fires (Hessburg *et al*. 1993, Covington and Moore 1994a). Firefighters have noted conditions in recent years that cause grave concern about their safety and their ability to control fires. While crown fires in ponderosa pine were almost unheard of earlier this century (Cooper, 1960), today they are commonplace. Table 2 quantifies changes by showing the numbers acres burned, and average fire size by decade since 1950. Pyne (1996) reports that crown fires increased from 10,127 acres per year in the 1940’s to 15,117 acres per year in the 1980’s, despite a massive commitment to high-technology firefighting. Society spends considerable resources (sometimes in vain) to stop these fires before they destroy not only natural resources but human developments as well.

**TABLE 2. Acres burned, and average fire size by decade on National Forest lands in Arizona and New Mexico, 1950-1996. (USDA Forest Service Data.)**

| Acres Burned | | Ave. Fire Size | |
|---|---|---|---|
| Decade | Total | Ave.-Annual | in acres |
| 1950-59 | 349,277 | 34,928 | 18.5 |
| 1960-69 | 238,955 | 23,896 | 11.5 |
| 1970-79 | 472,434 | 47,243 | 17.6 |
| 1980-89 | 329,296 | 32,927 | 15.9 |
| 1990-96 | 729,529 | 104,218 | 51.1 |

It is significant that the 3 largest fire years (in terms of acreage burned) since 1950 have occurred since 1993. Seven of the highest 1 1 years have occurred since 1988; two of the high years were in the 1950’s when fire suppression was likely less efficient**.** The actual increase in fire size and acreage accelerated rapidly in the late 1980’s.

Total fire starts and precipitation must also he considered. The number of tires has stayed fairly constant except for the 1970’s when it dropped slightly. The 1990’s have had drought years, but so did the 1950’s and 1970’s. Therefore, the recent high average fire size and acreage burned per year cannot be explained by either fire starts or precipitation.

Firefighting technology, road access, and suppression efforts have gradually improved since 1950. Therefore, major factors being about the same, a gradual decrease in acreage burned and average fire size would be expected. However, increasing vegetative density and the resulting fuel laddering appear to be primary reasons for the opposite trend.

Scientists who have studied the changes in vegetation and forest fires feel that fire will burn many forests in the Inland West. Sampson *et al,* 1993, state that only a few decades remain in which to save our forests, as most of the forests in the Inland West will burn despite elevated fire suppression efforts.

## IMPACTS OF DENSE FORESTS AND HIGH FIRE INTENSITIES ON OTHER VALUES

### Soil productivity

Dense Southwestern ponderosa pine forests may decrease available nitrogen (N) (Covington and Sackett, 1988). Accumulation of litter blocks recycling of organically bound N available for plant use in organic form. Since N is often a limiting factor, this may reduce productivity of ponderosa pine ecosystems. Where tires burn hottest, the greatest loss of volatile nutrients such as N also occurs (Covington and Sackett, 1988). “le fire helps make N available, the duration of benefit is less than four years; therefore, fires must occur on a 2- or 3-year cycle to enhance N availability and productivity (Covington and Sackett, 1988).

Coarse woody debris (CWD) is essential for ectomycorrhizal activity. While too little will reduce productivity, so will too much (Graham *et al,* in press). Optimum ranges presented by habitat type are most often exceeded in the Southwest in overly dense stands or following wildfires.

Fuller *et al.* (1955) report that high intensity fires consume much of the duff layer, exposing mineral soil to climatic elements that contribute to accelerated erosion. This makes difficult the reestablishment of many species of conifers. They also report that severe burning raises the pH level of the top two inches of soil by about one unit. Campbell *et. al,* 1977) report that in the year following burning, runoff carried about 1.7 tons per acre of suspended and bedload sediment from severely burned watershed, as compared to a few pounds from the moderately and unburned watersheds. This affects both soil productivity and water quality. Growth on surviving trees will be lower due to crown scorch, and tree regeneration will often be reduced or absent Campbell *et al,* 1977). In some cases, the result of extremely hot tires is a change in the ecosystem from forest to brushfield (Covington *et al*, 1994).

### Stream flow and water quality

The effects of more dense forests on stream flow is well documented. At Beaver Creek on the Coconino National Forest, researchers found that in ponderosa pine forests, on either Brolliar or Siesta-Sponseller soils, stream flow changed as follows with changing basal area (BA) (USDA Forest Service, 1974):

| Control | Change |
|---|---|
| Basal Area, (sqft/acre) | 120 100 60 40 0 |
| Streamflow, (percent change) | 0 4 17 25 35 |

Other researchers have also found increases in water yield after harvest to reduce vegetative density. At Workman Creek in Central Arizona, water yields increased with harvest (Rich and Gottfried, 1976). Baker (1986) found that increases at Beaver Creek diminish and then end in about seven years, due to water use from increases forage plants and young trees. However, **a** long-term cycle of harvest and prescribed fire should maintain much of the increase.

As discussed above, today’s forests are even above the baseline density used in the Beaver Creek study. This shows that they are providing less water for fish, riparian areas, groundwater recharge and downstream users than were the pre-settlement forests.

The results of this are evident in other ways too. Today, streams in the SW that were perennial a century ago do net flow year-round. Low flows in other streams are lower than they once were, with some intermittent streams drying up much earlier in the year. Low flows in turn affect water temperature and are a critical factor for fish and other aquatic life. However, where prescribes natural fire has occurred three or more times in the last two decades in the Gila Wilderness, streams are now flowing again that had not flowed for many years (personal communication, Steve Servis.)

Forest tires also affect many hydrologic processes. A 1978 (USDA Forest Service, 1979) study summarized the following: Water repellency increases with fire intensity, with more intense tires having the most effect. While removing vegetation normally increases soil moisture, Campbell *et. al.* (1977) observed reduced soil moisture in the upper 30 cm in an area severely burned, due to the repellency after fire. Debris flows increase following severe fires (Jensen and Cole, 1965; Klock and Healvey, 1976). During heavy rains, Campbell *et. al.* (1977) observed an eightfold increase in runoff from a severely burned watershed compared to an unburned watershed during heavy autumn rains. They also report that runoff efficiency (ROE), the ratio of runoff to precipitation, increases from 0.8 percent on an unburned watershed to 3.6 percent on a severely burned watershed. Compared to a moderately burned watershed, ROE c>n a severely burned watershed was 375 percent greater during the rain season and 51 percent less during the snow season.

### Archaeological Resources

Archaeological sites are also affected by hot forest fires. At the Henry Fire site in the Jemez Mountains, no effects were found on lithic artifacts, and ceramic artifacts were lightly sooted on lightly or moderately burned sites. However, in heavily burned sites, severe effects were present on artifacts, construction materials, and ground stone (Lentz *et al,* 1996). They concluded that where no heavy fuels burn in place, fire effects may be confined to the surface.

However, where there is increase fire residence time because of a log or other heavy fuel loads, subsurface artifacts can be severely affected.

Studies after the La Mesa fire of 1977 note several types of damage to archeological resources (Traylor *et al*., 1990). First, they found damage from fire suppression and rehabilitation. They also found that on-site vegetation intensified the burn and did more damage. They noted some of the fire's greatest damage was to tuff, the major construction material of Pajarito Plateau masonry sites. They feel that the damage to tuff alone is a good indicator of the severity of La Mesa Fire compared to past fires. Especially where fire burned hottest they found exterior surfaces flaking off and cracking. On one severely burned site, building stones had significantly deteriorated, losing much of their interior strength. Stones were so weak that they could not hold their own weight.

### Wildlife

Because of the highly varied environmental gradients and disturbance regimes, wildlife communities were diverse before settlernent (Covington *et. al,* 1994). Since then, some species have been extirpated others have declined and yet others increased in abundance. For example, antelope are believed to have declined as ponderosa pine forests became denser*. Other species that prefer open forests and may have declined include Grace's Warbier, Rock Wren, Western Woodpewee, and Chipping Sparrow (Finch *et al.* 1977). Today's dense forests should favor red squirrels and Mexican spotted owls. Some feel snag-dependent species may have declined; however, inventories today indicate that there may still he more snags than there were in 1910 when Woolsey found about 0.2 snags per acre greater than 18" in diameter.

The Southwestern Region of the Forest Service has a wildlife data base called RMWILD. This shows which species and groups of species use various habitats. It is notable that each canopy closure category and stand structure is used by large numbers of species. However, during this century, the amounts of grass/forb/shrub, seed/sap, and zero- to 40-percent canopy closure have drastically declined. It could be inferred from this that species that prefer vegetative stages and densities that have declined may also have declined. However, more work is needed to determine what specific changes have occurred.

### Susceptibility to insect and disease

Trees that are close together, like other organisms, are more susceptible to disease and to attack by insects than are wider-spaced trees (Sartwell and Stevens, 1975). This spacing was one mechanism that kept presettlement forests from being more severely attacked. Researchers have found that bark beetles, mountain pine beetle, Douglas-fir beetle, spruce budworm, and dwarf mistletoe are among those pests that expand as forests become more dense (Johnson, 1994). Mistletoes were always present but were kept in check by recurring fire (Alexander and Hawksworth, 1975).

## MANAGENENT NEEDS FOR SUSTAINABIILITY

There is no one simple solution to returning Southwestern forests to healthy, sustainable conditions; many techniques must be used. And, these techniques must he applied in a patchwork of small and large blocks to creme diversity, which has been largely lost over the past century (PM 1996). Miller (1996) points out that a management philosophy is needed that incorporates a range of stand density and structure, and that activities must be carried out in a variety of block sizes. Following are some actions that en he used to treat thew forests for sustainability:

**Prescribed fire.** Where prescribed fire can be properly controlled, it is a valuable tool in forest restoration. It is successfully used to reduce fuel loads and remove patches of trees.

**Wildfire.** Wildfires will occur. While some of the results will be negative, others will not and will help rectify the situation. For example, in many habitat types, they will help restore aspen to the ecosystem.

**Thinning.** Both pre-commercial and commercial thinning can reduce tree densities and, equally important, can remove or reduce lower canopy layers and thus reduce the likelihood of crown fire. Especially if done in a patchy pattern and in various size areas, it can greatly reduce homogeneity and enhance spatial and structural diversity (Edminister and Olsen, 1996). It proves useful in second-growth, even-aged stands, in overstocked, uneven-aged stands, and also in overstocked old-growth stands (Fiedler *et. al,* 1996).

**Harvests to mimic natural disturbances.** Thinning and prescribe fire are most often mentioned when looking for ways to improve conditions in Southwestern forests. However, we have to consider how each habitat type functioned naturally to know if we can perpetuate a forest. Group selection may be most appropriate for ponderosa pine, but not mixed-conifer. Howe (1995) points out that single-tree or small-group selection can result in dysgenic effects to the long-term genetic makeup of forests that regenerated naturally as even-aged such as SW mixed-conifer forests. He also states that pioneer species can be maintained in an uneven-aged condition only with very low stocking. In the southwest, aspen and ponderosa pine on white and Douglas-fir habitat types could suffer in the long term with uneven-aged management unless stocking is maintained at low levels.

**All of the above.** In the end, we must give all of the above tools to the on-the-ground manager rather than establishing regional or national policies about using any one or a certain combination of them. Based on conditions on a landscape, and on individual sites within that landscape, decisions can he made to enhance that area's sustainability and productivity. I include productivity here because for cons, humans have counted on their forest lands to provide for their needs and most land owners continue to expect that. It can be done along with sustaining the long term health of the ecosystem (Johnson *et. al,* in review).

Before many of these activities can he undertaken, socio-political change must occur. Prescriptive direction, such as the Mexican spotted owl (MSO) Recovery Plan and Northern Goshawk Guidelines, need to he adjusted or applied with flexibility considering pre-settlement condition and function of our forests. Where attitudes exist about meeting harvest targets in large trees, they must change. Current laws such as the Endangered Species Act (ESA), National Environmental Policy Act (NEPA), and National Forest Management Act (NFMA) can he used successfully by a handful of people to delay and stop activities that must he carried out. These laws were all passed with good intentions to provide protection for the environment, but change is needed in interpretations that, to date, have taken them beyond their authors' original intentions.

## CONCLUSION

Forests in the SW have lost much of their diversity; they have far more trees today than ever before, an unsustainable condition. This leads to severe, stand-replacing fires, followed by damage to resource values and decreased soil productivity. Water, sometimes considered the gold of the SW, is being used by the dense tree stands, reducing stream flows. Stand-replacing fires will increase flooding rather than restore normal flows. Wildlife populations change, favoring one suite of species over another. Cultural resource sites are damaged and sometimes destroyed by the hot fires.

We know what needs to be done to improve the situation- thinning, prescribed burning, harvest to mimic natural disturbances, and a combination of thew. Society has the resolve to suppress wildfires and provides hundreds of millions of dollars for this effort. This same resolve is needed to take the actions necessary to improve the health of our forests which in turn will reduce the need for firefighting. Power has been given to the few who want little to happen. This leads to future destruction of our forests if action is not taken soon.

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