Working Papers in Southwestern
Ponderosa Pine Forest Restoration

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Establishing Reference Conditions for Southwestern Ponderosa Pine Forests

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Working Papers in Southwestern Ponderosa Pine Forest Restoration

The Ecological Restoration Institute at Northern Arizona University is a pioneer in researching, implementing, and monitoring ecological restoration of southwestern ponderosa pine forests. These forests have been significantly altered through more than a century of fire suppression, livestock grazing, logging, and other ecosystem changes. As a result, ecological and recreational values of these forests have decreased, while the threat of large-scale fires has increased dramatically. The ERI is helping to restore these forests in collaboration with numerous public agencies. By allowing natural processes such as fire to resume self-sustaining patterns, we hope to reestablish healthy forests that provide ecosystem services, wildlife habitat, and recreational opportunities.

Every restoration project needs to be site specific, but the detailed experience of field practitioners may help guide practitioners elsewhere. The Working Papers series presents findings and management recommendations from research and observations by the ERI and its partner organizations.

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What Are Reference Conditions, and Why Do They Matter?

Restoring southwestern ponderosa pine forests revolves around reintroducing a regime of frequent, low-intensity fires like those that historically maintained forest structure and function. Such fires were rare in the twentieth century, due to livestock grazing and widespread fire exclusion. The resulting buildup of woody fuels has caused a widespread crisis in forest health, the effects of which include huge and unnaturally severe crown fires, bark beetle outbreaks, and declining biodiversity.

Restoration treatments that include prescribed burning, often preceded by thinning to reduce fuel loads, have the potential to improve the ecological health of these forests. In order to wisely set the goals that underlie these treatments, it is useful for us to know as much as possible about past forest conditions, especially the "reference conditions" that existed before forest structure and function were altered by Euro-American settlers. Such conditions were not unchanging, but they sustained themselves across what has been called a "natural range of variability" (Falk 1990; Landres et al. 1999). They formed the "evolutionary environment" of southwestern ponderosa pine trees—a fairly stable environment, in other words, in which this tree species and many other plants and animals evolved and adapted. Restoring conditions similar to those of the evolutionary environment is not a matter of trying to return to the past; rather, it is the only way to assure the long-term health of these forests into the future.

This publication provides ideas about how to determine some reference conditions for southwestern ponderosa pine forests, using both physical and cultural evidence. For more detailed information about finding and determining reference conditions for a variety of ecosystems, consult Dave Egan and Evelyn Howell's book *The Historical Ecology Handbook* (2001), upon which this publication draws heavily.

Limitations of Reference Conditions

Reference conditions can serve as an important guide for future management, but it is important to emphasize that reference conditions are not the same as restoration goals. Some types of reference information, such as detailed data about understory vegetation, small trees, wildlife, and the degree to which native peoples burned forested areas, are simply not available for most periods in the past. Even where reference conditions are known, it is often not possible to fully re-create the conditions present before Euro-American settlement, as climate change, extirpation of native species, habitat fragmentation, and the introduction of nonnative species have irreversibly changed contemporary conditions. In many cases, it might not be desirable to return to presettlement conditions, due to considerations of wildlife management, recreation, aesthetics, and other modern needs. For example, dense thickets of small trees can provide cover for wildlife and visual screening along roads or near houses. Above all, each restoration treatment needs to be site specific.

Reference conditions will never provide a recipe for forest management, but they can help set restoration and management goals. They can "help (1) define what the original or preferred condition (composition, structure, processes, function) was compared to the present; (2) determine what factors caused the degradation; (3) define what needs to be done to restore the ecosystem; and (4) develop criteria for measuring the success of restoration treatments or experiments" (Egan and Howell 2001). Clues about reference conditions are a particularly powerful tool when multiple lines of evidence are used to create a fuller picture than one type of evidence alone could.

Physical Evidence

Some of the best clues about what forests were once like occur in the forests themselves, in the form of contemporary forest structure and old trees, alive or dead, that indicate how that structure has changed.

Old Forest Remnants

One of the best ways to understand what a given forest area might look like under a restored fire regime is to analyze nearby areas that are less degraded and therefore more closely resemble what presettlement forests looked like. Parts of the North Rim of the Grand Canyon, for example, have never been logged, have not been grazed by livestock for many years, if ever, and have experienced wildfires on a regular basis. Some other large protected areas, such as parts of the Gila Wilderness and El Malpais National Monument in New Mexico and Zion National Park in Utah, have also been examined for important clues to the past of southwestern forests. Small remnant sites that can help illustrate what forest structures were once like may also exist elsewhere, such as on or near steep slopes where topography made logging or grazing impossible.

Comparing nearby forest stands to those sites can help quantify the changes in forest structure that have resulted from modern management practices. It is important not to extrapolate too much from such sites, though, as forest structure and fire regimes can vary a great deal in a small area, especially where topography or other ecological conditions are varied.

Physical Remains of Old Trees

Trees present before Euro-American settlement are an obvious source of information about forest structure at an earlier time. While many of the trees standing at that time have either been logged or died naturally, their remains often persist for many decades in the arid climate of the Southwest. Searching for these remains can help establish some of the most accurate records of past forest structure.

Living trees. The bark of ponderosa pine trees generally begins to turn yellow at about a hundred years of age (White 1985). For that reason, it is often possible at a glance to gain a rough idea of a stand's age. Most restoration treatments being implemented in the Southwest call for retaining and protecting all yellow-barked pines, since these old trees are among the rarest resources in southwestern forests. Though no such guide exists for the Southwest, two useful publications that are available online detail how to determine the age of ponderosa pines in the Colorado Front Range (Huckaby et al. 2003a and 2003b).

The growth forms of ponderosa pines can also aid in reconstructing past forest structure. For example, trees grown in open conditions typically have full, rounded crowns and relatively long, thick branches (Figure 1), while trees grown in a closed forest more often appear long and narrow. These appearances persist even if stand conditions later change. A few old, open-grown pines surrounded by a sea of smaller, younger trees likely indicates that forest structure was once more open than it is now.

Figure 1. *The thick, horizontal limbs of this old pine show that it grew in the open.*

"Catfaces" or visible fire scars on old trees can provide valuable insights into the past fire history of forest stands (Figure 2). Such scars often preserve evidence of many fire events, which can be dated using the dendrochronological techniques described below.

A comparison of the species represented by old and young trees can also be telling. Near Flagstaff, for example, a study took place in ponderosa pine forest in which presettlement remains of fire-intolerant white fir (*Abies concolor*) were quite rare, yet the modern forest supports many young white firs (Fulé et al. 1997)—supporting the hypothesis that a lack of frequent fires in the twentieth century has changed both forest composition and structure.

Figure 2. *"Catfaces" such as this preserve records of past fires.*

Snags. Dead trees can stand for many years in the Southwest, particularly if they are large (Figure 3). They provide important wildlife habitat for such species as bats and cavity-nesting birds. Their size, age, and growth form provide the same sorts of clues to forest structure as living trees.

Figure 3. *Like a living tree, this snag records growth forms that shows how it grew.*

Figure 4. *Downed logs can remain on the forest floor for many decades, providing clues about old forest patterns.*

Downed logs. Especially where fire has long been absent, fallen logs can persist for decades on the forest floor (Figure 4). They can indicate the position, size, and age of old trees. In some parts of the Southwest it is possible to find stumps 16 or 32 feet away from remnants of tree tops, indicating that early loggers removed only the commercially valuable lower sections of trunk wood.

Stumps. Most of the Southwest's large ponderosa pines were cut during the nineteenth and twentieth centuries, but in many places their stumps still persist (Figure 5). Their size gives an idea of the size and species of the trees removed; their rings can be cross-dated to establish their age and growth rates; their spatial arrangement reflects forest structure before logging. The size of stumps can also reflect more modern forest history. Stumps cut before the introduction of chainsaws (generally in the first half of the twentieth century) are often chest-high, much higher than modern ones, as they were generally cut by loggers using handheld saws.

Stump holes. Where fires have passed or decay has occurred, the locations of large trees are often recorded for some time by the presence of stump holes (Figure 6) that show where trunks and roots grew.

Taken together, these records of old trees can be extremely valuable in reconstructing what was present at a time when frequent surface fires remained the primary architect of forest structure. In practice, field observations have often been combined

Figure 5. *Stumps record the locations of now-vanished trees, and their growth rings can provide data similar to those of standing trees.*

Figure 6. *Holes where stumps burned or decayed can persist for many years.*

with dendrochronological dating of tree rings (see below). Even without that level of detail, modern-day observers of forest conditions can reconstruct a number of important aspects of historic forest structure, including tree density and size and to what extent trees grew in clumps.

Dendrochronology

In dry southwestern forests, trees often grow at differing rates in wet and dry years. A study of the growth rings preserved in their wood can provide a detailed look at past climate, fire regimes, and forest structure (Figure 7; Kipfmueller and Swetnam 2001). Dendrochronological techniques have been used to gain an increased understanding of past forest conditions at many sites in the Southwest (Swetnam and Baisan 1996).

By combining field observations of tree remains with dendrochronological cross-dating techniques, researchers have been able to reconstruct past stand conditions at a number of sites in southwestern ponderosa pine forests, including along the Mogollon Rim in central Arizona (Covington and Moore 1994), near Flagstaff (Fulé et al. 1997; Menzel and Covington 1997; Mast et al. 1999), at the Grand Canyon (Fulé et al. 2002), in the Uinkaret Mountains in far northern Arizona (Waltz et al. 2003), in the San Juan Mountains of southwestern Colorado (Romme et al. 2003), and in the Jemez Mountains in New Mexico (Allen 1998). Two excellent general guides to dendrochronology are Schweingruber (1988) and Stokes and Smiley (1996); there are also several good online guides, including
http://web.utk.edu/~grissino/default.html,
http://www.plantbio.ohiou.edu/epb/instruct/ecology/dendro.htm, and
http://www.ltrr.arizona.edu/dendrochronology.html.

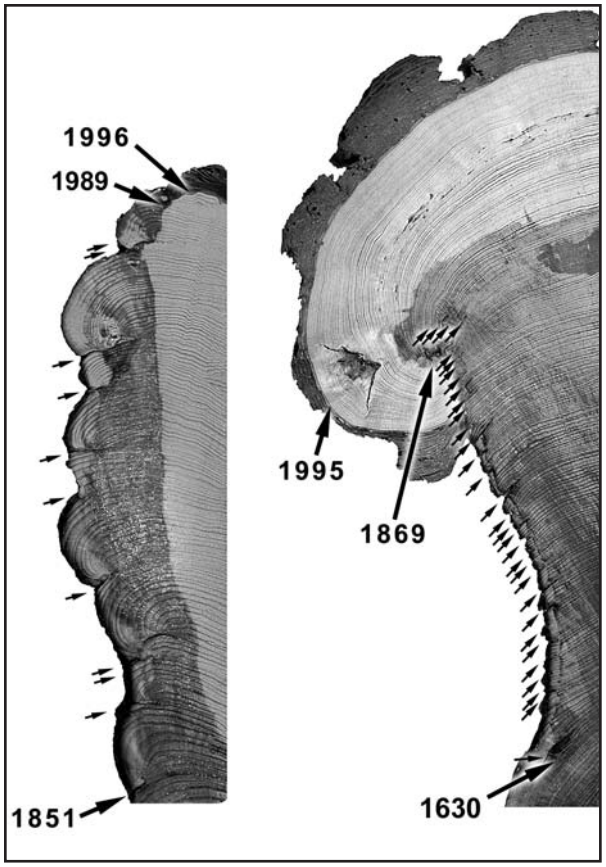

Figure 7. *Pine fire scars from Durango, Mexico (left), and Mount Trumbull in the Uinkaret Mountains of northern Arizona (right). Arrows indicate rings with fire scarring; outermost dates indicate when the fire scars were collected. In Mexico, fires continued at regular intervals through the twentieth century. In northern Arizona regular fires ceased with the onset of large-scale livestock grazing, with the last fire occurring in 1869. Photograph by Dan Boone/Northern Arizona University.*

Cultural Evidence

Written, photographic, and oral history evidence can provide significant insights into past conditions. Records of southwestern ecosystems are fairly accurate compared to those of many other parts of North America, since most of the Southwest was not explored or settled by Euro-Americans until the nineteenth century. As a result, many types of records can help indicate what southwestern forest conditions were like before the onset of heavy livestock grazing, logging, and fire exclusion.

Early Written Records

Various types of written records abound in libraries and archives, including records of early Spanish explorations, nineteenth-century survey expeditions, local histories, and the journals of early settlers. To find them, enquire at local or university libraries. Local historical societies may also be able to provide pointers about where to find resources for your area. Two bibliographic guides specific to the Southwest are Kaminkow (1975) and Rittenhouse (1971); look for them at a university library.

Many early written records are quite detailed and present a good description of what the landscape looked like. For example, Vernon Bailey wrote this account of the Jemez Mountains in northern New Mexico in 1904: ". . . generally an open park like forest with well spaced trees and clean grama turf beneath. The trees are large and symmetrical, often 5 feet in diameter and 80 to 100 feet high with beautifully smooth trunks" (quoted in Allen 2002). Such a description can be helpful in setting

restoration goals. However, it is important to note that this is a *qualitative* rather than a *quantitative* description. It does not present any measurements of forest structure. It does not record the number of trees per acre, nor whether the trees are clumped or evenly spaced. It does not indicate what other plants besides ponderosa pines and grasses were present. In other words, it is not an exact description, and it is certainly not an exact restoration prescription.

It is also important to remember that historical accounts may utilize different species names than we know today; for example, ponderosa pine may be referred to either as yellow pine or western white pine.

General Land Office Surveys

Surveys of most lands in the Southwest were conducted in the nineteenth century by the federal General Land Office, the precursor of the Bureau of Land Management (BLM). These surveys identified and marked section corners and resulted in the recording of extensive data about the vegetation of areas surveyed, as surveyors were required to record basic descriptions of the vegetation they traversed along section lines. This information can be valuable in assessing how the structure or composition of forests and woodlands may have changed in the intervening decades. As an example, Arundel (2000) used GLO records from 1878 and 1879 to assess the distribution of forest stands and meadows, the percentage of various tree species, tree densities, and tree diameters in an area near Flagstaff—information that could be useful in setting restoration goals.

Copies of surveys for the southwestern states are generally available at state BLM offices. For an overview of the use of GLO data, see a helpful chapter by Whitney and DeCant (2001). Galatowitsch (1990) writes specifically about using GLO records in western landscapes.

Forest Service Records

After the establishment of the Forest Service in the early twentieth century, the new agency commissioned timber surveys of new national forests in the Southwest and elsewhere. The surveys were intended primarily to quantify how much usable timber was available. Some of them include considerable detail about the tree species present, the density and size of stands, and other forest conditions. Long-term plots set up by early Forest Service researchers on some southwestern national forests are a particularly rich source of data (Moore et al. in press).

To locate such inventories, contact the supervisor's office of the national forest in your area. The Forest Service report *Timeless Heritage* (Baker et al. 1988) has an extensive bibliography of early agency publications; so does the Web site of the National Archives at **http://www.archives.gov.** The online archive of the Forest History Society at **http://www.lib.duke.edu/forest/archmain.html** is also a valuable resource.

Oral Histories

A great deal of information about ecological conditions exists in the minds and memories of people who have not recorded their experiences in written form. Native Americans, ranchers, and other local residents often have long traditions of use and observation of the land that do not exist in writing, but may be of great relevance to contemporary management. Oral histories can, for example, reveal what sorts of land management practices were used in the past, and may give an idea of how ecological conditions have changed over time.

Local libraries and historical societies often have collections of transcribed interviews conducted in the past. The recording of formal oral histories properly requires a protocol, described by Fogerty (2001). When seeking oral history information from any informants, it is important to remember that it may take a good deal of time to build the trust necessary for a useful interview. Cultural sensitivity is key; for example, in some Native American communities certain stories are told only at certain times of year. It's also good etiquette to give something back, for example by making oral histories available to the community in which they were acquired.

Figure 8. *Photographs of the same forest stand before and after it was changed by modern land-management practices can help quantify changes over time, and can aid in setting restoration goals. Walker Lake, Coconino National Forest, Arizona, in the 1870s and 2003; 2003 photo courtesy of Dennis Lund and Neil Weintraub.*

Photographs

Historic photographs are among the most useful of records in understanding changing forest conditions. Photographs from the late nineteenth and early twentieth centuries can show what conditions existed before significant ecological changes took place. It can be particularly valuable to rephotograph the same landscape shown in a historic view; for example, images of Walker Lake on the Coconino National Forest show a greatly increased density of ponderosa pine between the 1870s and 2003 (Figure 8). Some researchers have also used aerial photographs taken in different decades to assess changes in forest density over time.

When looking at historic photographs it is important to consider the land uses that went on before the photos were taken. A photograph of a forest that was selectively logged or heavily grazed will not accurately represent what the forest structure was like before those land uses were instituted. Differences in photographic technology may also make scenes in historic photographs appear different than they do in today's photos; for example, many old film types were unable to record wide differences in exposures, with the result that areas that appear light-colored in a contemporary photo may be entirely washed out in an old one.

To find historic photographs, contact libraries, historical societies, and local offices of the Forest Service, BLM, or other federal, state, or tribal land management agencies. Two useful Forest Service Web sites with archival photos are **http://www.fs.fed.us/r3/about/history/photo.shtml** and **http://www.rmrs.nau.edu/imagedb/index.shtml.**

Conclusion

A variety of opportunities exist for uncovering reference conditions for southwestern ponderosa pine forests. By using several of the techniques described above, researchers and managers can develop converging lines of evidence. For example, written records may be lacking for a given area, but an examination of both historic photographs and contemporary forest structure can provide insights into historic conditions. Whatever is learned about reference conditions will not provide an easy recipe for restoration or management. It will, though, help establish how a forest area once sustained itself, which is an important step in deciding how to make forest conditions more sustainable once again.

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For More Information

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