Peeled Ponderosa Pine Trees at the Warm Springs, Battle of Cieneguilla Site, New Mexico

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Abstract

Forty-four cross section samples of peeled ponderosa pine trees from the Warm Springs area on the Carson National Forest, New Mexico were tree-ring dated. It is likely that these trees were peeled for food or medicinal purposes by the Jicarilla Apache. Fire scars were also present on many of the samples, and a combined analysis of the peeling scars and fire scars was carried out. The peeling dates ranged from 1777 to 1893, with a peak in peeling dates in the 1820s to 1850s. This timing generally corresponded with an extended period of conflicts between Jicarilla Apache, Spanish and Americans. Numerous surface fires occurred in this area before and after the peeling events, but there were no obvious changes in fire occurrence associated with the peeling activity. The years when trees were peeled were both wet and dry with no consistent pattern, while the years with fire scars were generally dry. Trees were typically peeled during the early and middle part of tree-ring cambial growing season. Fires occurred both before and during the growing season. Additional study of peeled trees in combination with better replicated fire history studies from the same areas may help identify influences of human presence and activities on past fire regime changes.

Introduction

Peeled ponderosa pine trees can be found in scattered locations around northern New Mexico, but in general, they are somewhat rare. These living artifacts were created by people peeling the bark from the boles of mature ponderosa pine trees to extract the soft and nutritious layer of phloem and cambium. This "inner bark" was consumed, probably as a food source, or possibly for medicinal or other purposes (Swetnam 1984, Martorano and Beardsley 1993, Corral 1996, Östlund et al. 2009). We know from dendrochronology studies that this practice was carried out during the 18th and 19th centuries by Native Americans in the Southwest, including Apache, Ute, Navajo, and Zuni people (Swetnam 1984, Kaye and Swetnam 1999, Towner and Galassini 2012). Multiple historical and ethnographic sources, some dating to first-hand observations by non-natives in the early and mid-19th century, refer to inner bark use as a hard times or famine food, but this is not a consistently cited reason for inner bark use (Swetnam 1984). From oral interviews with elderly informants, Corral (1996) also documented Picuris Pueblo and Hispano use of inner bark in northern New Mexico, and this practice may have continued into the early 20th century.

Despite the multi-cultural uses of inner bark, and statements by some informants that it was considered a sweet delicacy, extant peeled ponderosa pine trees are relatively rare. If pine inner bark had been an important and frequently used food source, it seems that these artifacts would be much more common in forest areas of the Southwest than they are. The relative rarity of peeled trees in New Mexico today may be related to some combination of factors, including: 1) tree peeling was restricted to certain times of the year, and possibly also to certain years, such as when people were hungry or in need of the medicinal effects of inner bark; 2) only certain places had trees that were relatively palatable, such as areas near water sources where sap flow was greater; 3) only small amounts of inner bark were harvested and eaten at any given time; and 4) logging, forest fires and other disturbance events have removed most peeled trees from the forest landscape.

Peeled trees in New Mexico have generally been found in small groups of a few to a dozen or more trees, but in at least two places they exist in groups of more than 70 trees. One of the largest groups of peeled trees is in Chimayo Canyon, located near Chimayo, NM, where at least 70 peeled trees were counted and a few of them were tree-ring dated (Swetnam 1984). The other, and largest known group of peeled trees is in the Warm Springs area just northwest of Picuris Pueblo. According to Corral (1996) Forest Service archaeologists identified 561 peeled trees in this area. A timber sale and logging operation in the late 1980s provided an opportunity to dendrochronologically analyze the largest collection of cross section samples of peeled trees yet obtained in the Southwestern US. Forty-two tree-ring samples from peeled trees were obtained by Dr. Jon Young, forest archaeologist, Carson National Forest, and were sent to Dr. Tom Swetnam, dendrochronologist, at the University of Arizona, Tucson. Graduate students (at the time) John Maingi and Theresa Newberry carried out most of the original tree-ring crossdating work on the specimens, with assistance from Chris Baisan at the University of Arizona. Maingi and Swetnam (1993) prepared a report detailing the dating results of the specimens and provided that to Dr. Young. In addition to dates of all peeling scars in the cross sections, Maingi and Swetnam reported dates of fire scars that were also present.

Patricia Corral (1996) carried out a master's thesis project at New Mexico Highlands University, Las Vegas on the ethnographic and historical aspects of peeled trees in Northern New Mexico, and she utilized the Warm Springs tree-ring data from Maingi and Swetnam (1993) in her study.

In this report, I describe the results of a re-analysis of the Warm Springs peeled tree cross sections. In addition to describing the peeling and fire scar dating results, I examine the seasonal timing of these scarring events and the possible association between the peel dates, fire dates and drought variability in northern New Mexico. Last, I describe the potential for further study of peeled trees in northern New Mexico in combination with fire history studies.

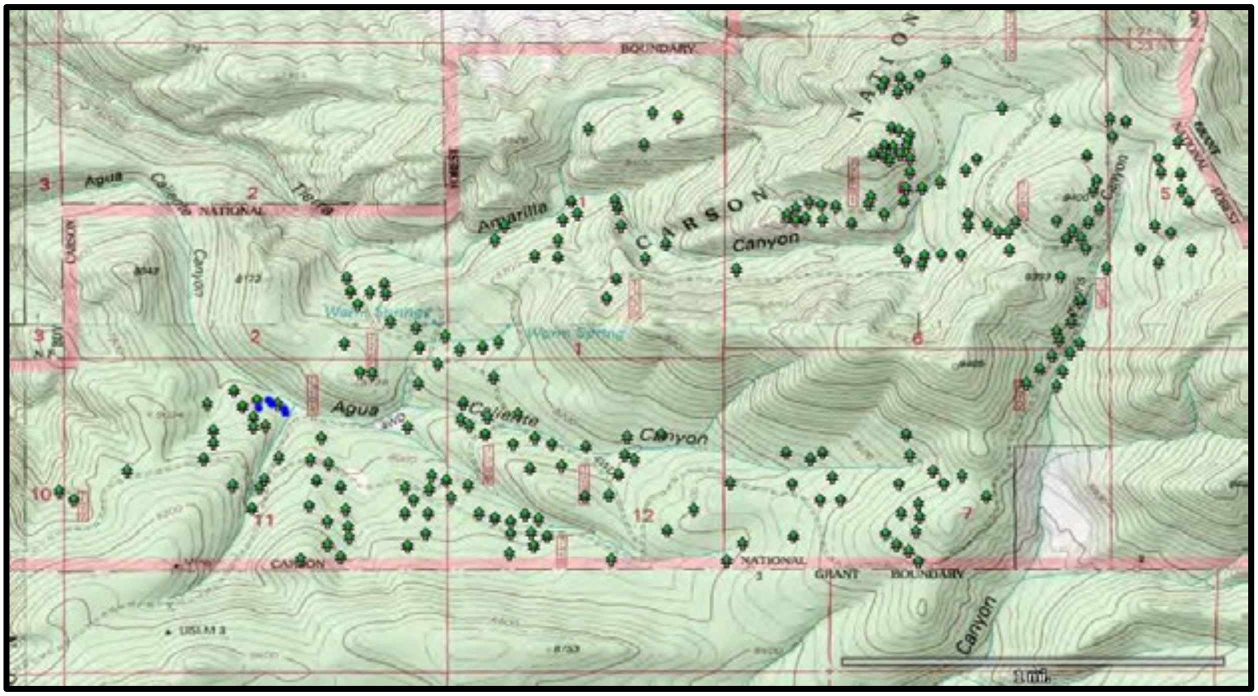
Study Area Description

The Warm Springs peeled tree area is located about 5 km (3 miles) northwest of Picuris Pueblo. The elevation of the area ranges from about 2,400 m (7,800 ft) to 2,900 m (9,400 ft). The topography is a set of east/west and southeast/northwest trending ridges and shallow canyons comprising the Agua Caliente and Tierra Amarilla Canyons draining to the west into the Rio Grande. Ponderosa pine (*Pinus ponderosa*) is the dominant tree species, with some juniper (*Juniperus scopulorum*) and Douglas-fir (*Pseudotsuga menziesii*) also present, especially on northern aspects and the canyon bottoms. Various riparian trees are also present, including cottonwood (*Populus fremontii*). All peeled tree samples were ponderosa pine.

More than 230 peeled trees were mapped and measured in the area by the Forest Service and Patricia Corral for her master's thesis (Figure 1).

Figure 1. Map of the Warm Springs area, showing locations of 232 inventoried and measured peel trees in Carson National Forest cultural-modified trees database. Blue symbols show locations of seven additional specimens we collected in 2016. These trees were probably recorded as "isolated

occurrences” in the Forest Service inventory system. Presumably, the remaining trees of the total 500-plus peeled trees in the area were distributed in groups around this same area.



The Warm Springs area includes the site of the 1854 Battle of Cieneguilla. This was a military engagement between a troop of U.S. Army Dragoons and a large band of Jicarilla Apache (Johnson 2009). The Dragoons were routed by the Apache, losing 22 soldiers and 23 wounded. The number of Apache killed and wounded is unknown. It was one of the largest defeats of the U.S. Army by Native Americans during the 19th century. The presence of the Jicarilla Apache encampment at Warm Springs in 1854 suggests that the peeling of ponderosa pine trees in this area during this era may have been carried out by them. It is also possible that Ute, Navajo, Hispano or Picuris people harvested inner bark from trees in this area.

The vicinity of Picuris Pueblo is also known as a place where people gathered the clay and minerals for producing distinctive micaceous pottery. The abundant presence of mica and feldspar minerals is obvious on the ground surface in the Warm Springs area. The long-term connection of the Jicarilla Apache and micaceous pottery is suggested in the name “Jicarilla” applied by the Spanish, which means literally “little chocolate cup”. The Jicarilla did not use chocolate in this era, but they produced a “little cup” made of micaceous pottery that was popular as a trade item. The Jicarilla inhabiting the western part of northern New Mexico were also known as the “Olleros”, meaning “potters”, whereas the Jicarilla living on the east side of the mountains were known as the “Llaneros”, or “plainsmen” (Nunez-Velarde, http://jicarillaapachepottery.com/History.html) .

Methods

The cross-section samples were reduced in width and size on a band saw, and then one cross sectional surface on each specimen was sanded with belt sander using grits up to 400. A variable power binocular microscope was used to evaluate all annual rings, peeling scars, and fire scars. The skeleton plot method was used for crossdating ring patterns in the cross-section samples with master tree-ring width chronologies from northern New Mexico. The calendar dates and scar dates were marked on the cross sections by pinpricking holes for decades and centuries and by writing dates in pencil on the surfaces. All cross-section samples were boxed and inventoried in the Laboratory of Tree-Ring Research (LTRR) archival system, with the three-letter code "WSP" appended to all specimen numbers that were originally marked on the samples by Forest Service collectors.

All specimens that were original tree-ring dated at LTRR were re-examined by me (T.W. Swetnam) for the current study. I checked the crossdating (tree-ring pattern matching) of all specimens, and dating and identification of the peeling scars and fire scars. I also determined the seasonal timing of scars by observing the position of injured cells and characteristic scar features within annual rings (Dieterich and Swetnam 1984, Margolis et al. 2017). The intra-ring (seasonal) scar positions were labeled as: "Dormant", occurring between latewood cells of the previous ring and earlywood cells of the subsequent ring; "early-early wood", occurring within the first one-third of the earlywood cells; "mid-earlywood", occurring within the second one-third of earlywood cells; "late-earlywood", occurring within the third one-third of earlywood cells; "latewood", occurring within the latewood type cells. Some of the intra-ring scar positions could not be determined because of very narrow rings, resin or decay; these were labeled as "unidentified".

Although Maingi and Swetnam reported all fire and peel dates, their report did not include data on seasonal (intra-ring) scar positions.

In addition to the cross-section samples obtained by Jon Young and originally examined by Maingi and Swetnam, I obtained an additional collection of cross sections from seven fire scarred trees (and one of these specimens also had apparent peeling scars, WSP105A).

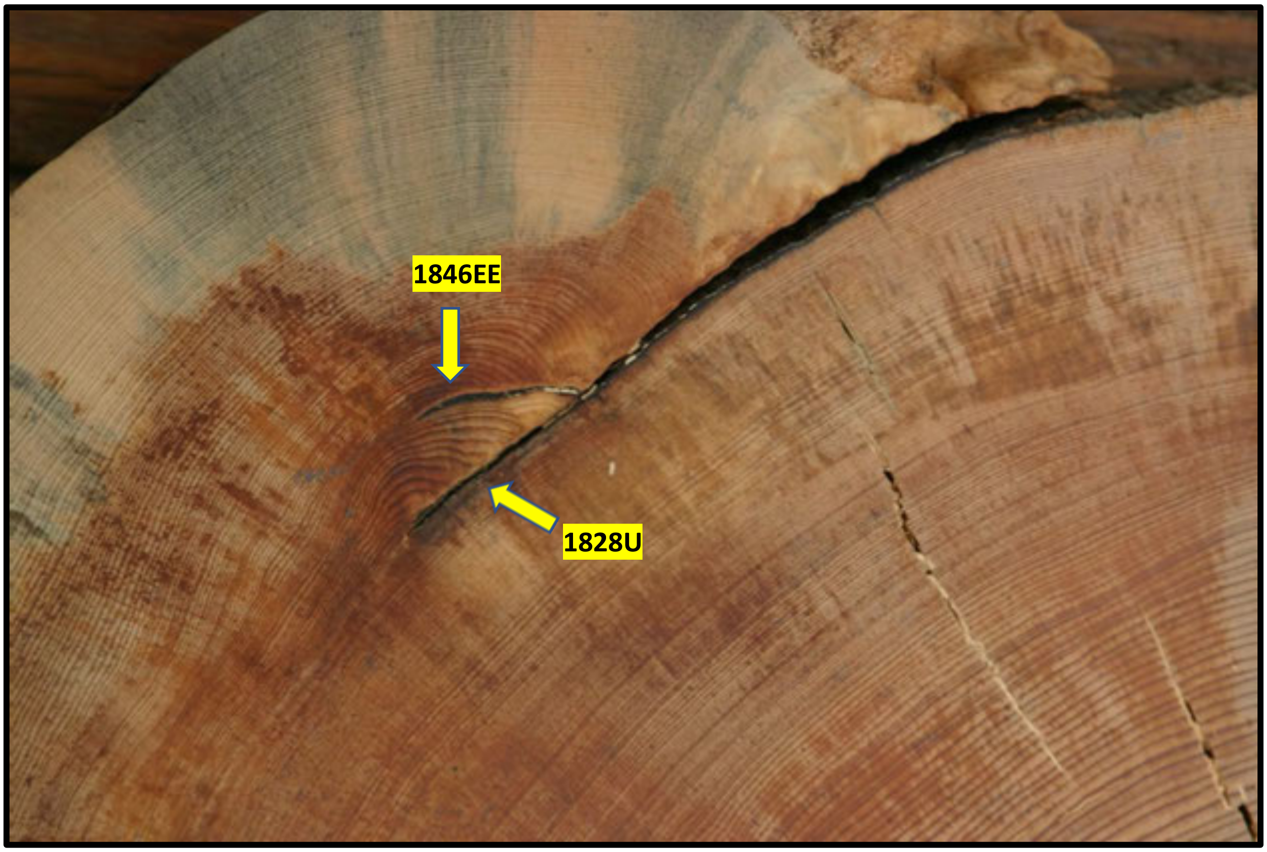
A spatial database provided by the Carson National Forest was obtained that shows locations of 232 of the 561 peeled trees in the Warm Springs area. From Corral's (1996) descriptions, it seems the tree-ring samples and possibly also the mapped trees in this database (Fig. 1) were recorded as "isolated occurrences" in the Forest Service system. Using the isolated occurrence ID numbers, which correspond to labels on the cross sections and assuming these numbers correspond with the numbers in the USFS digital database, I mapped the dates of peelings to see if there was any spatial clustering of peeling dates.

To assess possible associations of peeling and fire event years with drought conditions I used the North American Drought Atlas grid point 133 (centered over northern NM) time series (Cook et al. 2004). This is a reconstruction of summer Palmer Drought Severity Index from tree-ring width chronologies, and the period extending back to 1600 CE was used in this study.

Results

Most of the peeled trees also contained fire scars. This is probably because the peeling wounds resulted in copious amounts of resin flow out of the wound boundaries, and this resin provided a ready pathway for spreading surface fires burning up to the base of the tree and onto the exposed wood of the peeled bole. Many of the exposed wood surfaces of peeled trees show charring from these past fires that ignited and burned for some time on the surfaces. Consequently, peeled tree wounds commonly incurred one or more fire scars in years and decades following the peelings (Fig. 2).

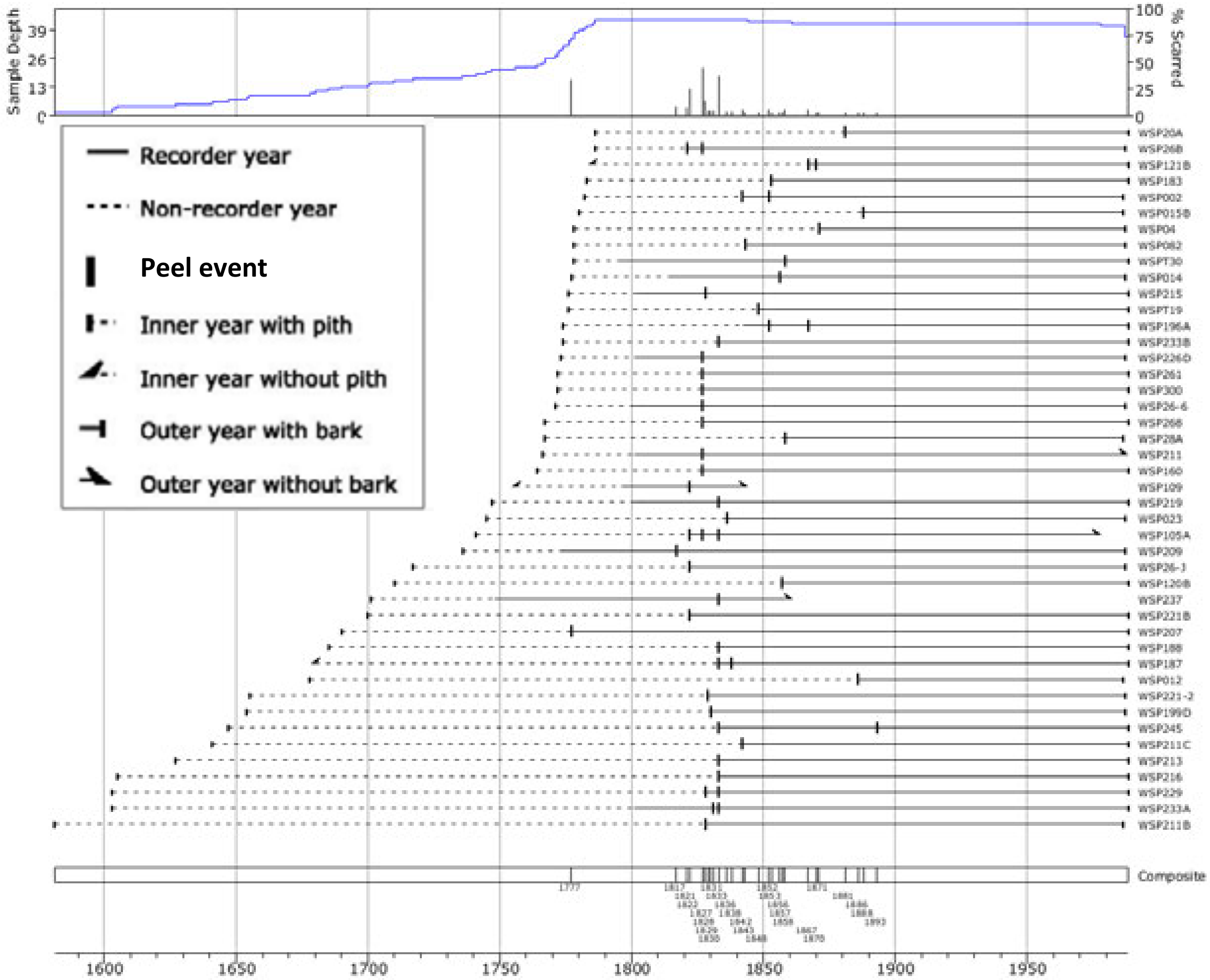
Figure 2. Photo of peeled tree cross section sample WSP-211B with both peel and fire scars. The first, larger scar in 1828 (U for "unidentified" intra-ring position) is a peeling scar, and was followed by a fire scar event in 1846 (EE for early-earlywood intra-ring position). This is a typical example, with a much larger (in circumference) peeling scar, followed by a smaller fire scar (or multiple fire scars) formed along the healing edge of the peeling scar when fire ignited on the surface of the peeled bole. In effect, the peeling event made these trees highly susceptible to being re-scarred by surface fires burning through the stand.



Chronologies of Peel and Fire Events

The master chronology of 44 dated cross sections shows peeling dates extending from 1777 to 1893, with notable clusters of peeling dates from the 1820s through the 1850s (Fig. 3). (These 44 specimens are all the tree-ring datable material that I examined, including specimens that originally came from the USFS collection and the new samples I obtained in 2016.) Fire scars were recorded earlier than peel dates in twelve cases out of the 44 dated trees. These cases are identifiable in the chart as trees with a solid horizontal line preceding the first peeling date (vertical tick marks). Commonly, these fire scars were "buried" inside the bole, with subsequent ring growth completely covering the scars. The subsequent peel scars were then observed as separate wounds oriented along a different radial axis, and not apparently associated with the previous fire scar wound area.

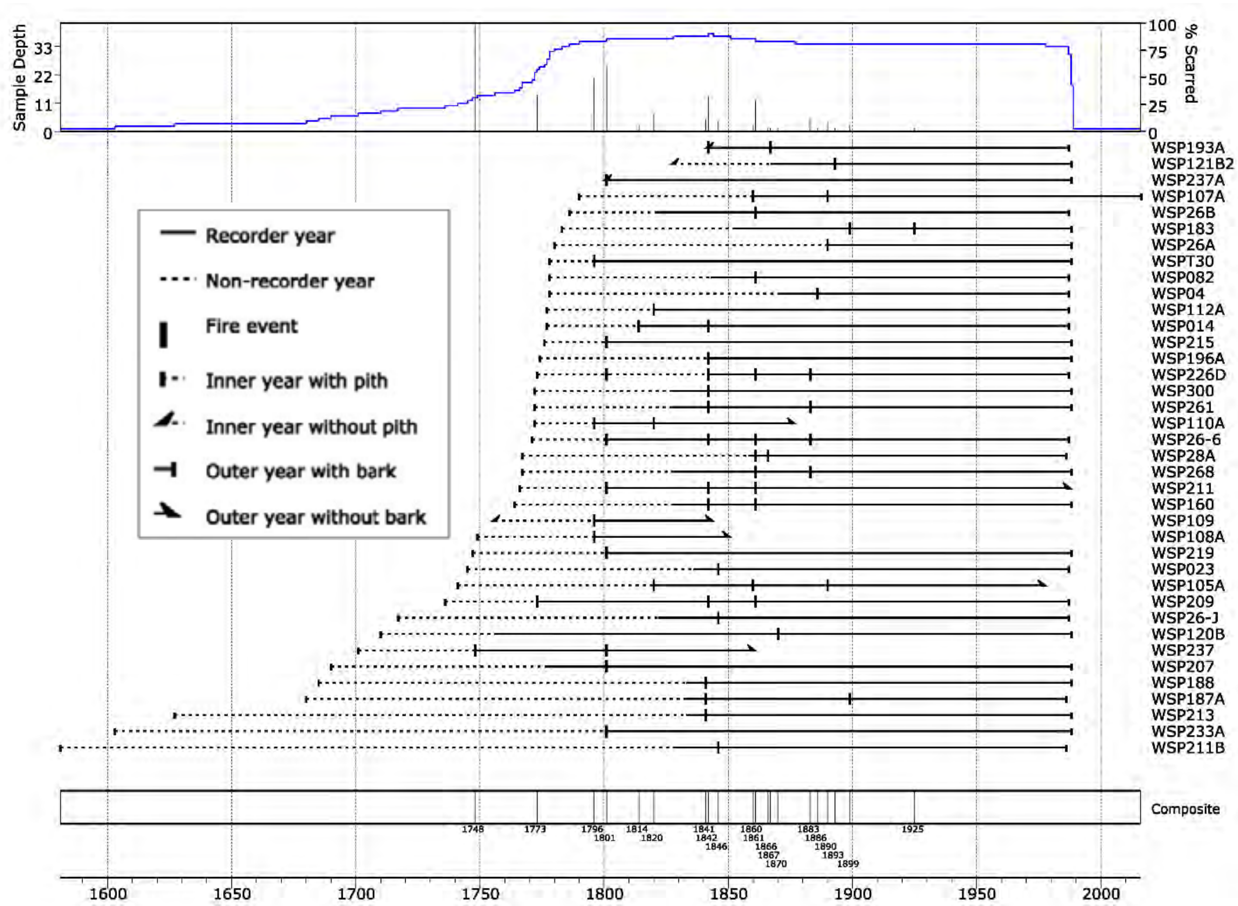
Figure 3. Master chronology of peeled tree dates from Warm Springs. The “Composite” at the bottom shows all peel dates as vertical lines and labels.



Thirty-eight of the 44 peeled scar specimens also had fire scars, and 18 of these trees previously recorded a peel event before they were fire scarred (Fig. 4). Again, the trees that had previously recorded a peel scar are identifiable in the chart as those trees with a solid horizontal line preceding the first fire scar event (vertical tick marks). The fire scar dates range from 1748 to 1925.

Several trees recorded multiple peeling events. These usually appeared as separate wounds along different radial axes, i.e., not as the typical peel followed by a fire scar along the same radial axis (as in the example in Fig. 2). In other words, trees that were peeled a second time (or even a 3rd time, as in WSP105A) were peeled on the opposite side of the tree from the earlier peeling. The specimen WSP105A was collected by me (and Lane Johnson and Ellis Margolis), and so I examined it in detail before and after sampling. Fire scars were identified from another cross-section from the same tree taken at near ground level (dating to 1820, 1860, and 1890). The section containing the peel dates was higher on the stem (about 1 meter height), and these dates were 1822, 1827, and 1833.

Figure 4. Master chronology of fire scar dates from Warm Springs. The “Composite” at the bottom shows all peel dates as vertical lines and labels.

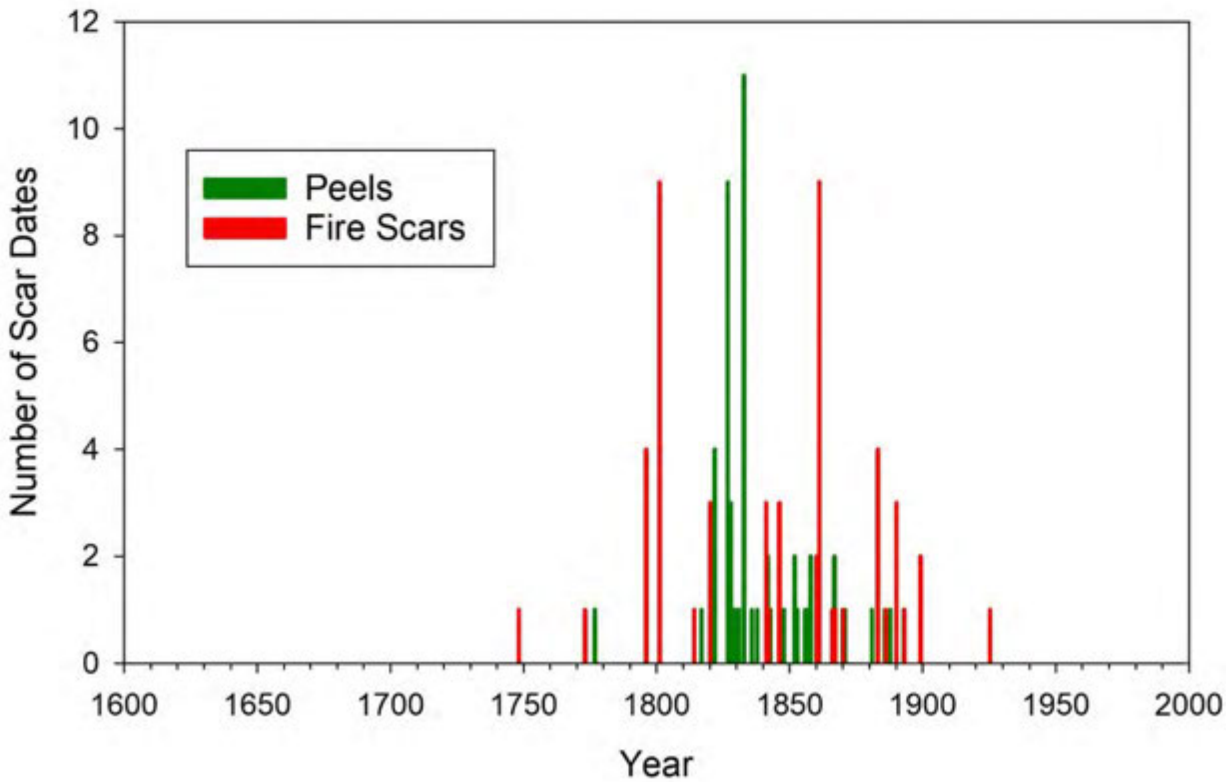


The composite time series of numbers of trees peeled and fire scarred each year since 1600 shows both fires and peeling events occurring frequently throughout the period from about 1750 to 1900 (Fig.5). There is no obvious temporal association between peel events and fire events (or vice versa). Peel events occurred more frequently than fires, especially during the 1820s through 1850s. Widespread fires burned in some years, as indicated by higher numbers of trees (>3) scarred during those years (i.e., 1796, 1801, 1820, 1841, 1846, 1860, 1883, 1890).

The years 1827 and 1833 are notable as years with most frequent peeling (9 and 11 trees, respectively). Other years with more than 3 trees peeled were 1822, 1828, and 1831.

Overall, it appears that the primary period of tree peeling extended from the 1820s through about 1870. Interestingly, no trees in the sample set were peeled during 1854, the year of the Battle of Cieneguilla. However, the 44 trees in this set of specimens were a relatively small proportion of the total number of peeled trees in the area, so perhaps other trees were peeled that year. There were a small number of trees in the sample set with dates in 1852, 1853, 1856, and 1858. Also, the Battle of Cieneguilla was on March 30, 1854, and as noted later in this report, most peeling of trees occurred during the growing season (about May to August). Trees peeled in March or April would appear as “dormant” season scars.

Figure 5. Time series of peel and fire scar dates at Warm Springs. Showing numbers of trees peeled and fire scarred each year, 1600 to 2000.

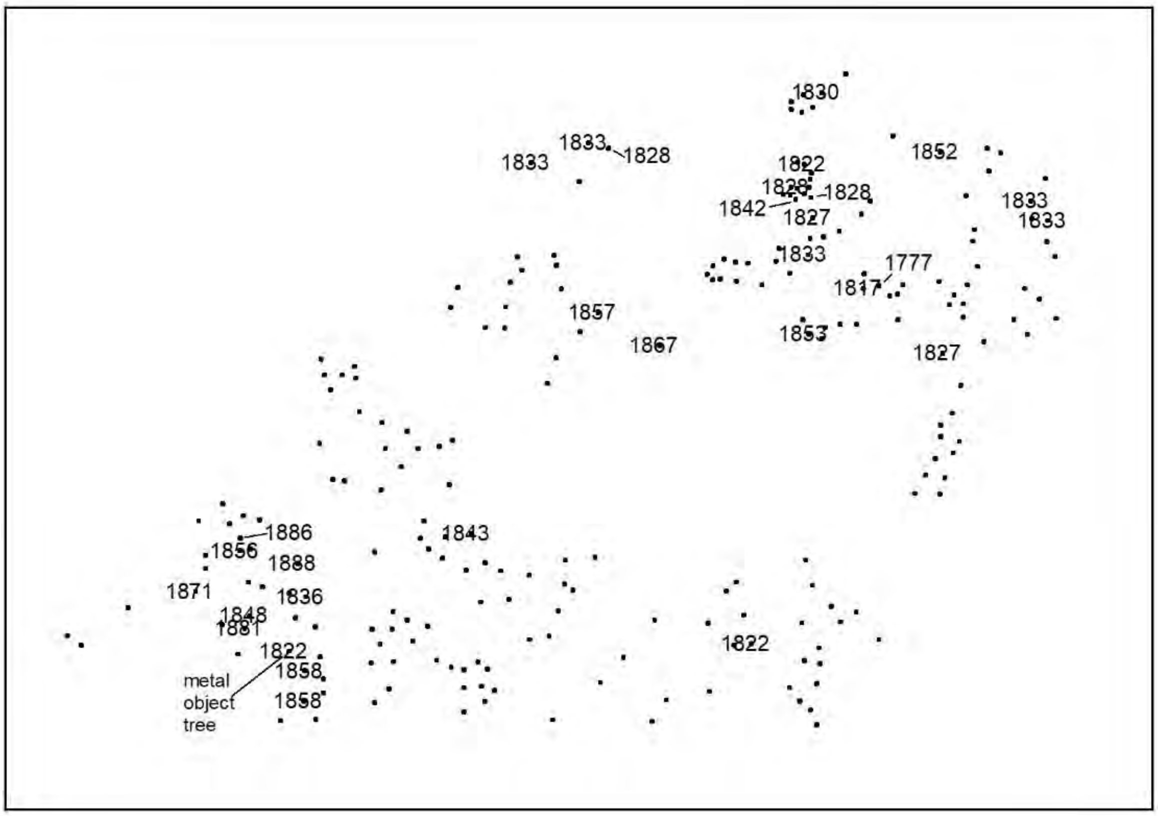


Spatial Pattern of Peel Dates

The spatial patttern of peeling dates does not show a strong clustering of dates, but there is a tendancy for earliest dates, and especially 1820s to 1830s dates, to occur in the northeastern portion of the Warm Springs area (Fig. 6). This is the upper portion of Tierra Amarilla Canyon (see Fig. 1). The earliest peeling date in 1777 was in this area. The latest peeling dates in the 1870s-1880s occur in the southwest portion of the area. There are, however, some 1820s-1830s dates in the southwest portion as well.

Overall, the mapped trees in this USFS spatial database comprise under half of all identified peeling trees in the area (232 of 561 total peeled trees), and the sampled and dated trees comprise only 44 of the 232 mapped trees. So the tree-ring sample of peeled trees is about 8% of the total, and the spatial or temporal biases of this particular collection are unknown.

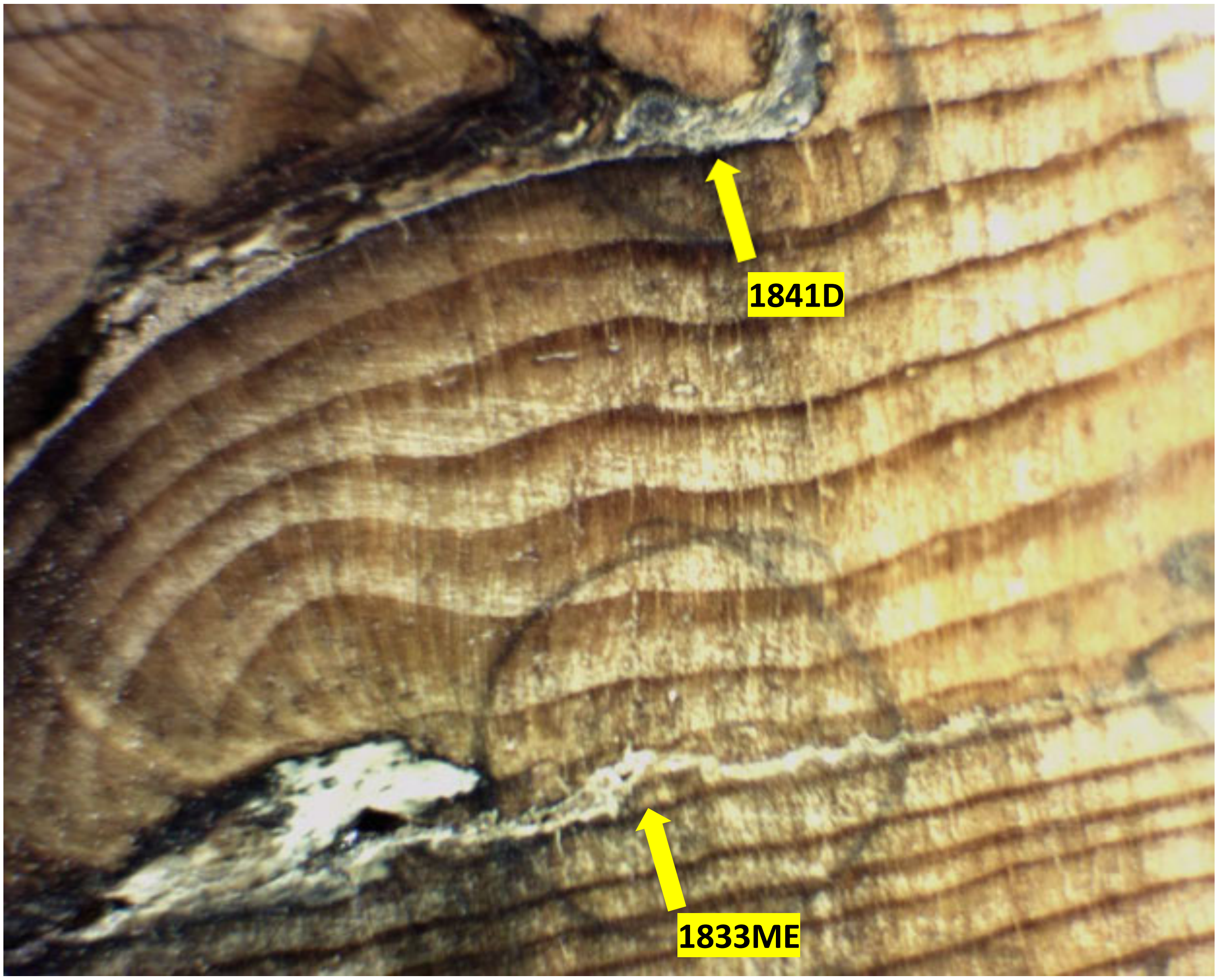
Figure 6. Map of 232 "Isolated occurrence" recorded peeled trees in the Carson Nattional Forest CMT database at Warm Springs, showing the dates of sampled and dated peeled trees. The location of the tree (WSP26J) with the metal object embedded in the 1767-1769 rings is also shown.



Intra-Ring/Seasonal Timing of Peels and Fires

The intra-ring position of approximately 80 percent of the peel scars and fire scars were confidently determined (see examples in Fig. 7). The remainder could not be identified due to very narrow rings, and/or resin or decay in the ring(s) containing the injury.

Figure 7. Closeup view of a middle-earlywood example of peel scar at 1833 and a dormant season fire scar in 1841, specimen WSP188. Note the peel scar in 1833 appears as a somewhat ragged line of earlywood cells preceding a crack that appears white from the fine sawdust inside it. That is a somewhat typical appearance of a peeling scar. In contrast, the 1841 fire scar appears as a lesion occurring immediately after the latewood cells of 1840 and before the earlywood cells of 1841, i.e., during the dormant season.

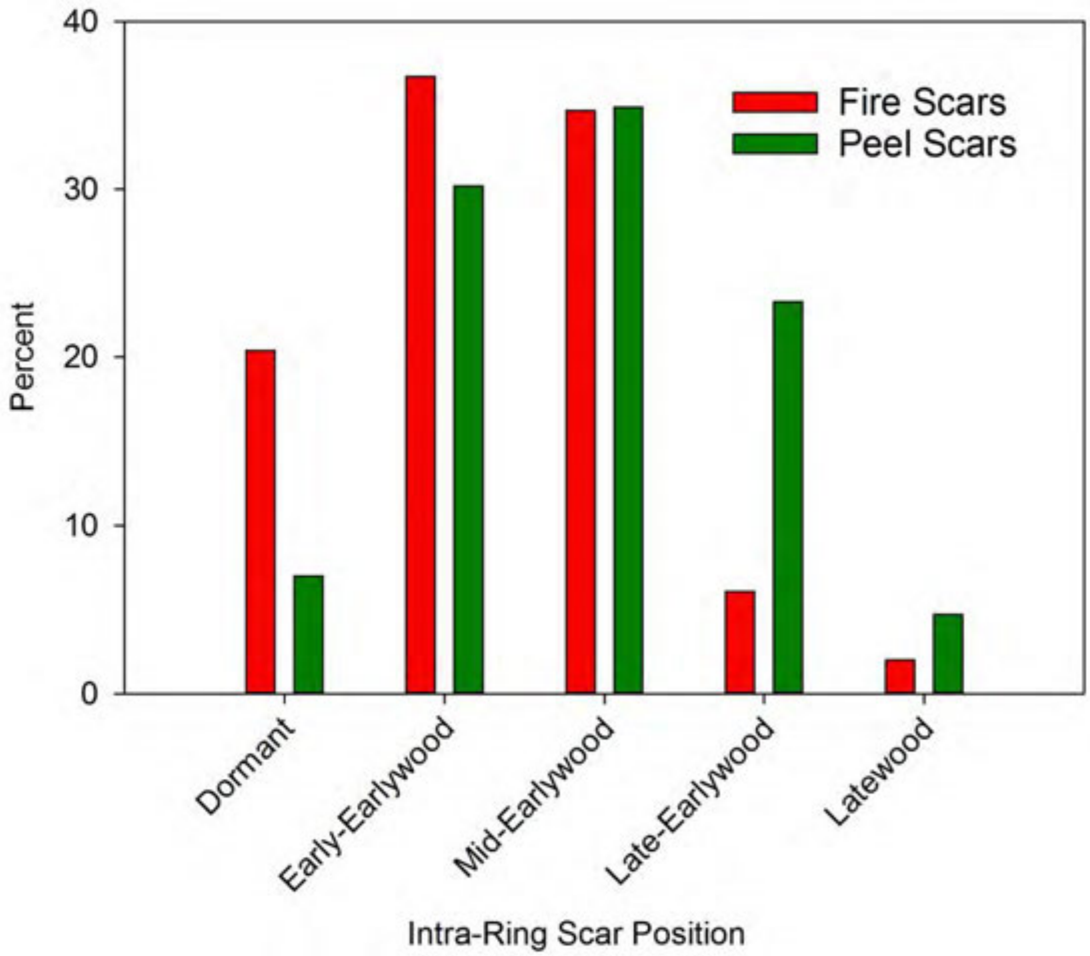


The distribution of intra-ring position of fire scars generally coincides with observations from other studies in the Southwest, with most fires occurring within the dormant, early-earlywood, and mid-earlywood portions of the ring, and a much smaller percentage occurring late in the earlywood or in the latewood (Fig. 8). The scars with the dormant through mid-earlywood intra-ring positions occurred approximately in the spring through early summer (i.e., April through June for fire scars).

The most interesting result here is that the peeling events generally occurred somewhat later than fire events, with very few peelings occurring during the dormant period (i.e., before approximately May). Most peeling events occurred during the early to middle part of the growing season (i.e., late May or June).

This makes sense given that the peeling was for obtaining the soft phloem and cambium layers (inner bark). These layers are thickest and softest during the early and middle part of the growing season, when many cells have already divided, are filled with water and nutrients, and have not yet lignified. A late spring to early summer timing of peeling generally corresponds with descriptions by Native American and Hispanic informants (Corral 1996).

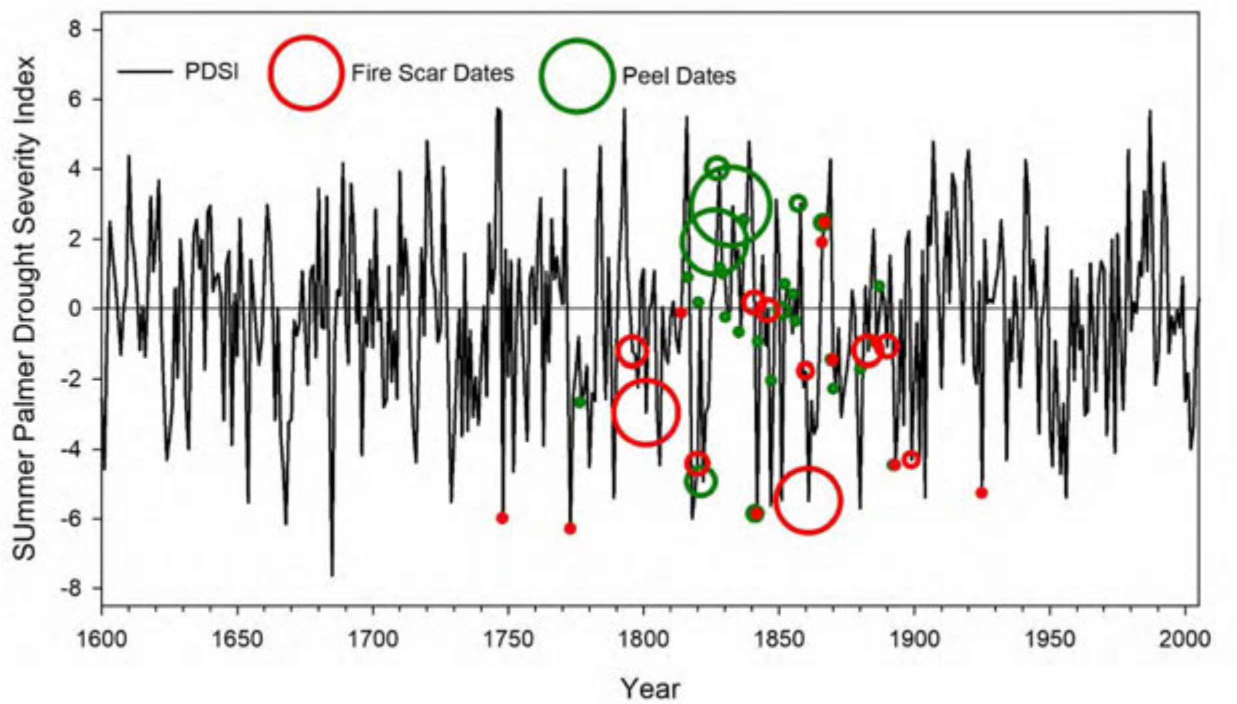
Figure 8. Frequency distribution of intra-ring/seasonal timing of peel and fire scars.



Drought Associations with Peel and Fire Events

Peel events seemed to have no association with dry or wet conditions during the year of the peeling, but fire events tended to occur during dry years (Fig. 9). Of 27 peeling event years, 13 occurred during dry years and 14 during wet years. The 3 years with the most trees peeled (1827, 1828, 1833), however, all occurred during relatively wet years. In contrast, of the 20 fire event years, 18 occurred during dry years while only 2 occurred during wet years.

Figure 9. Comparison of peel tree and fire scar dates with Palmer Drought Severity Index time series for northern New Mexico. Negative PDSI values are drier than average, and positive are wetter than average. The circle sizes are scaled to the largest and smallest peel or fire years, based on numbers of trees scarred in those years (see Fig. 5).



Metal Object

During the process of checking the crossdating of annual rings and scar identification I noticed an interesting feature in specimen WSP26-J (Fig. 10). This is a square metal object that measures slightly more than 2 mm on a side, and it is embedded within the 1767, 1768 and 1789 rings. From microscopic examination I can see that this object was first emplaced within cambial and xylem cells of the 1767 ring, i.e., that is the year the object impacted/entered the tree. Cell growth in 1768 and 1769 proceeded over and around the object, with the object completely covered by the early growing season of 1769.

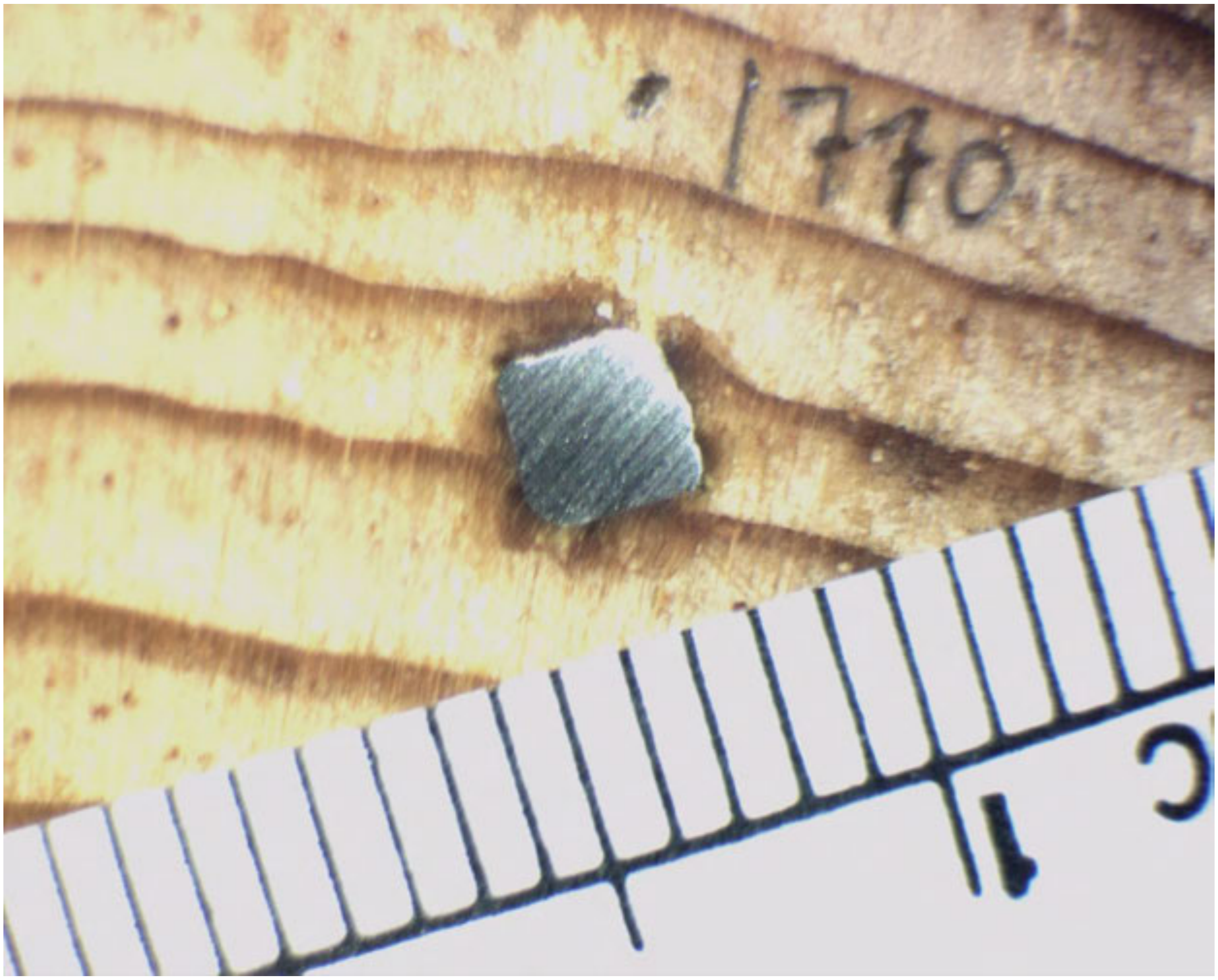
The object is slightly attracted to a magnet, suggesting that it is ferrous (iron?) rather than lead.

It seems possible that it could be either: 1) a nail hammered into the tree, or 2) a piece of "shot" that came from a firearm (e.g., a musket). From the apparent angle of the object, as seen in cross section view (Fig. 10), it seems unlikely that this is a nail pounded into the tree. If it is a nail, it would have had to be inserted at nearly a vertical angle, almost parallel with the bole of the tree (rather than perpendicular to the bole). Alternatively, it could be a nail that was pounded in above or below this point, and was bent downward or upward, and the cross-section view shows where the tree grew around the bent portion of the nail.

If it is a piece of iron shot from a firearm, it seems it only penetrated the bark and entered the active cambial zone during the 1767 growing season (summer). The object appears only on one side of this approximately 4 cm thick cross section.

The object could be extracted from the cross section for further analyses, but for now it remains in place, and this section has been prepared as an interpretive display for the Carson National Forest. If the object is dug out of the wood, it might be possible to determine if it is a nail or shot, and the metal could be analyzed to determine composition.

Figure 10. Closeup view of metal object imbedded in 1767-1769 rings, specimen WSP26J. The ruler scale is marked in millimeters and centimeters.



Discussion and Conclusion

Peeling/Fire Timing, Seasonality and Drought Associations

Re-scarring by fire of previously peeled trees is common, as we have also observed in other cases in New Mexico ponderosa pine forests (e.g., Kaye and Swetnam 1999). The copious resin flow from peel wounds most likely provides a ready pathway for surface fires to ignite on the exposed and pitchy surfaces of the peeling. Despite the common occurrence of fire scars on the sampled peeled trees, the chronologies of fire and peel dates show no obvious association over the entire sampled area. That is, we do not see a clear pattern of peel and fire scar dates coinciding in time (same years), or of widespread fires occurring immediately before or after peeling dates. There were a few cases of fire scars occurring during the same years as peeling dates, but most peeling and fire dates occur in different years.

The fire scar chronology from Warm Springs is undoubtedly incomplete. Ordinarily, to develop a complete inventory of widespread fire events we systematically search for the best preserved and oldest trees with maximum visible fire scars, and spatially distributed throughout the study area. Spatially unbiased fire scar sample designs have also been used, including sample points or plots in a grid, transect or random patterns, and equal search time per amount of area sampled. In the case of Warm Springs, the fire scar chronology was opportunistically developed from fire scars that happened to be recorded by trees that were peeled and sampled because they were peeled, not because they had good fire scar records.

It would be desirable to obtain a larger sample of fire scarred trees from the area, systematically collected from the highest quality and well distributed samples, so that we might further examine the possible interactions of people and fire in this area. For example, with a more complete fire scar sampling and chronology we could assess changes in fire frequency and fire seasonality in relation to human presence, as indicated by timing of peeling events. A similar study in the Sacramento Mountains, NM showed that fire seasonality was probably affected by human presence (Kaye and Swetnam 1999).

(Regarding other fire and peel scar chronology comparisons, see Appendix A to this report. There I have included analyses of the peeling and fire scar chronologies from a site near El Valle, NM, which is about 9 miles to the south of Warm Springs. El Valle fire scar chronology is much more complete than the Warm Springs fire chronology, and vice versa for the peel chronologies. Also, Appendix A includes a comparison of peel tree dates from Warm Springs, El Valle, and several other locations in northern New Mexico that might all be attributed, at least in part, to Jicarilla Apache inner bark use.)

The most consistent temporal pattern detected in the Warm Springs samples was (1) a moderate tendency for fire events to occur somewhat earlier in the growing season than peeling events (Fig. 8), and (2), a strong tendency for fire events to occur during dry years, with no association between wet/dry years and peeling events (Fig. 9). These findings are generally in accord with other studies in the Southwest on peeling/fire seasonality (Kaye and Swetnam 1999) and fire seasonality and drought associations (Margolis et al. 2017).

Cultural Interpretations of Inner Bark Use

Patricia Corral's study is a remarkable contribution to the literature on inner bark use. She summarized the historical and cultural uses of pine inner bark across the western US, and she analyzed the large data set of measurements of peeled tree scars (sizes, shapes, etc.) at Warm Springs to evaluate possible culture-related patterns in scar morphology. She also conducted interviews with elderly Hispano, Picuris and Jicarilla Apache people on the uses of inner bark. Her findings on scar morphology were interesting, but did not conclusively show that scar shape could be used to discriminate Native American versus Hispano origin of scars.

Despite concerted efforts Corral had limited success in finding or recruiting either Picuris or Jicarilla Apache informants, and ultimately, she interviewed only one person from each tribe who had knowledge of inner bark use. She was more successful with Hispanic people, and interviewed 6 individuals with knowledge of inner bark use. The interview results were quite interesting, and confirm that Hispanic and Picuris people also carried out this practice. It was already well-established that Apache people (e.g., Western Apaches in southern NM and Mescalero Apache in the Sacramento Mountains, Swetnam 1984, Kaye and Swetnam 1999) and Ute people (Martorano and Beardsley 1993) practiced the peeling of ponderosa pine trees. Further, the occurrence of peeled trees in scattered locations known to be used as campsites of Jicarilla Apache people (including Warm Springs, and Chimayo Canyon, Swetnam 1984), establishes inner bark use by this group with high confidence.

Although interviews of Picuris and Hispanic people from villages near the Warm Springs area establish their cultural use of inner bark, it is unknown if any of the peeled trees in the Warm Springs area were peeled by them. All things considered, I suspect that Warm Springs peeled trees that were included in the tree-ring dated sample set primarily reflect peeling by Jicarilla Apache people, rather than Picuris or Hispanic. The reasons for this are chronological and historical.

It is especially notable that the earliest peeled tree in the Warm Springs sample set was peeled in 1777. This fits a general pattern in the dating of all known peeled trees so far in New Mexico, i.e., earliest dates are in the late 1700s, and more typically, dates tend to begin and peak in the early to mid-1800s (Swetnam 1984, Kaye and Swetnam 1999, Sheppard et al. 2016, and unpublished data, see Appendix A). If Hispano or Pueblo people were peeling trees in the Warm Springs area, why are there no earlier dates during periods when we know they occupied villages in this region (i.e., for multiple centuries in the case of Picuris)? Ponderosa pine trees in the Warm Springs area are certainly old enough to have been peeled in the pre-1770s period, and as early as the 1600s (see tree ages in Figs. 2 and 3, and also the charts in Appendix A). There are also no peeling dates in this data set from the early 20th century, which is generally the period of recollection of peeling by Corral's interviewees.

It is possible that, for some unknown reason, the practice of peeling ponderosa pine trees for the inner bark was introduced to, or initiated by, all three groups of people in the late 1700s (i.e., Picuris, Jicarilla Apache, and Hispanos). That might help explain why no peeling scars before that time have yet been found in northern New Mexico (See Appendix A). It seems more likely (to me) that the peeling during this period is associated with conflicts and warfare, i.e., hard times.

The historical literature on Jicarilla Apaches, including the accounts of the 1854 Battle of Cieneguilla, make it clear that the Warm Springs area was a campsite used by the Jicarilla during this era, in part for accessing micaceous clay for pottery that they made and used as a tradeware. Historical reviews also mention that the Jicarilla and other aligned tribes were often in conflicts with Comanches prior to 1778, when a peace treaty was arranged. There were multiple other conflicts between the Jicarilla and American trappers and traders that began to travel through this region of northern New Mexico during the 1820s and 1830s. The 1850s was especially contentious, with multiple battles between the US Army and the Jicarilla. In Taylor's (1969) account of 1850s military encounters with the Jicarilla in northern New Mexico, he notes repeatedly the important role that food scarcity and hunger among the Jicarilla Apache was a factor in the strife during that era (pages 269, 270, 285). (See Appendix A, Fig. A6 for a proposed historical narrative of Jicarilla Apache movements in relation to peeled tree dates from multiple sites in northern NM.)

As Corral (1996) and others have concluded (e.g., Towner and Galassini 2012) single year peeling dates from New Mexico (Zuni Mountains in case of Towner and Galassini) generally do not show clustering of dates in certain years that are clearly associated with drought, which might be expected to be hard times or famine years. Sheppard et al. 2016, however, noted that the decadal periods of peel scar dates during the 1850s and 60s at a site near the Philmont Boy Scout Camp (about 30 miles east of Taos) were generally dry. Peeling dates from Warm Springs were almost evenly distributed between wet and dry years (Fig. 9), and the largest years for peeling (1822, 1828, 1833) were generally wet. However, as previously mentioned, this multi-decadal period from the 1820s through 1850s, and later, were generally characterized by warfare and conflict. Fighting between the Spanish and the Jicarilla, and then the Americans and Jicarillas continued sporadically until 1887 when the Jicarilla were finally settled on a reservation west of the Rio Grande near Dulce, New Mexico.

The final peeled tree dates at Warm Springs were 1886, 1888, and 1893. The final peeled tree dates in the Sheppard et al. study at Philmont were 1876 and 1877. The final peeled tree dates at El Valle, NM site (9 mi south of Warm Springs) were 1869 and 1877. Peeled tree dates at Escondido Canyon (36 miles northwest of Warm Springs) were 1872, and the peel tree dates at Chimayo Canyon (23 miles southwest of Warm Springs) were 1857 (Appendix A).

Future Work

There are many other peeled trees and peeled tree sites in northern New Mexico that could be studied to learn more about their historical and cultural origins. Both the Carson and Santa Fe National Forest (and Valles Caldera National Preserve and other NPS units) have database records of these trees. It would be highly interesting and perhaps revealing of human history to dendrochronologically date as many of these living artifacts as possible, while they are still present on the landscape. Wildfires and other disturbances will inevitably erase these records of human history. It is possible to sample and date peeled trees non-destructively by taking increment cores (Swetnam 1984). Partial or full cross sections are most desirable for dating scars. These might be obtained from already dead peeled trees (i.e., logs or snags) without the same concerns about sampling living peeled trees with a chain saw. Further, it would be most interesting to obtain well-replicated fire scar collections from some of the same sites where peeled trees are present. By searching for old, well-preserved fire scar samples, it should be possible to reconstruct fire history in much greater detail and historical time depth, than was possible with the set of fire dates obtained from Warm Springs peeled trees alone. With combined peel history and detailed fire history from the same stands, I expect we will learn more about the ways that long-time human presence (or absence) affected fire frequency and seasonality in ponderosa pine forests.

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Appendix A

Analyses of Peeled Tree and Fire Scar Data from El Valle, New Mexico and Comparison of Peel Tree Dates from Various Sites Across Northern New Mexico.

Figure A1. Peeled tree scar chronology from near El Valle, NM. Note the pattern of a few earliest scars in 1774, 1780 and then peels throughout the period of circa 1810s to 1870s. These samples were mostly from dead peeled trees, i.e., logs and snags, and a few were dated with increment cores from living trees.

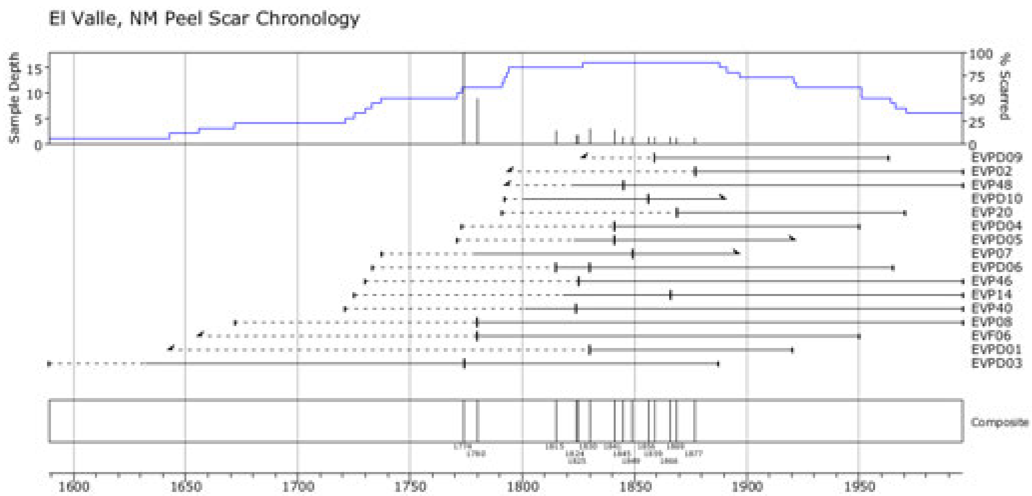
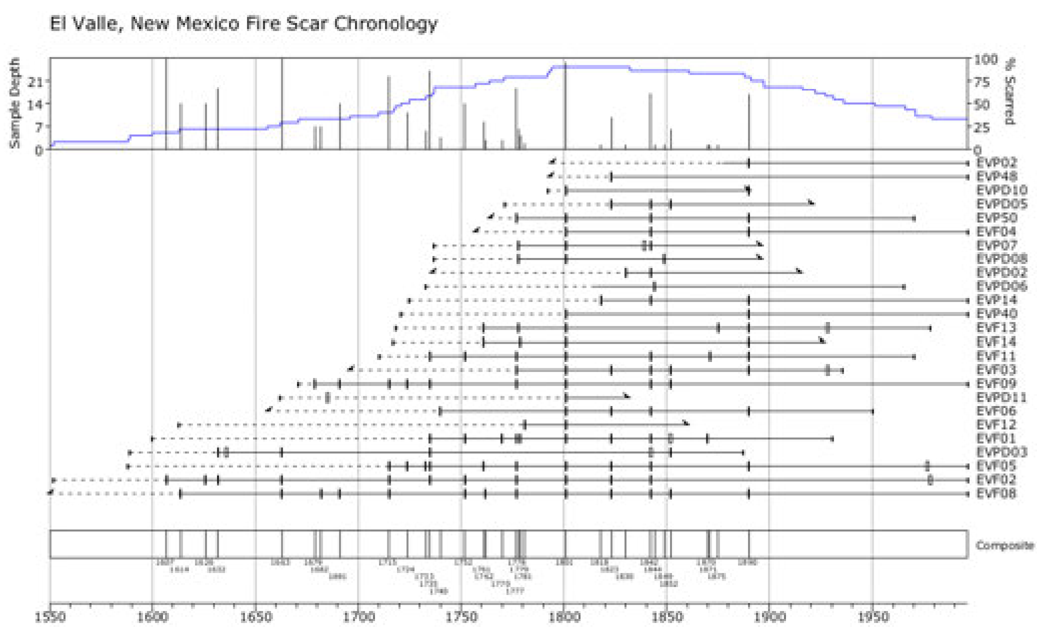


Figure A2. Fire scar chronology from near El Valle, NM.



Appendix A, for report: Peeled Ponderosa Pine Trees at the Warm Springs, Battle of Cieneguilla Site, New Mexico, T.W. Swetnam, June 18, 2017

Figure A3. The seasonal timing of fires versus peels at El Valle is similar to the pattern observed at Warm Springs, i.e., fires tended to occur earlier in the year (Dormant season), and most peeling was late spring or early summer.

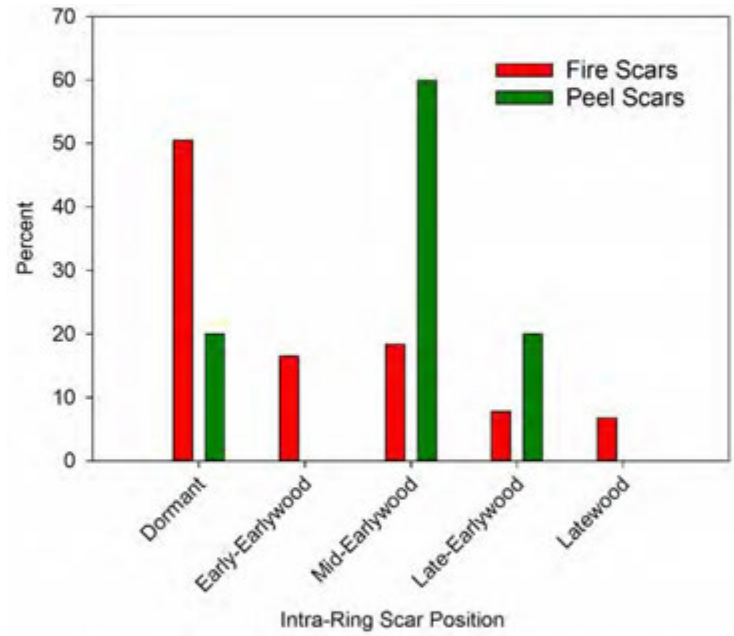


Figure A4. Comparison of summer PDSI (grid point 133 from NADA, Cook et al. 2004) with peeling and fire scar dates from El Valle, NM. As observed with the Warm Springs data, peel dates show no clear association with PDSI, but most fires occurred during dry years.

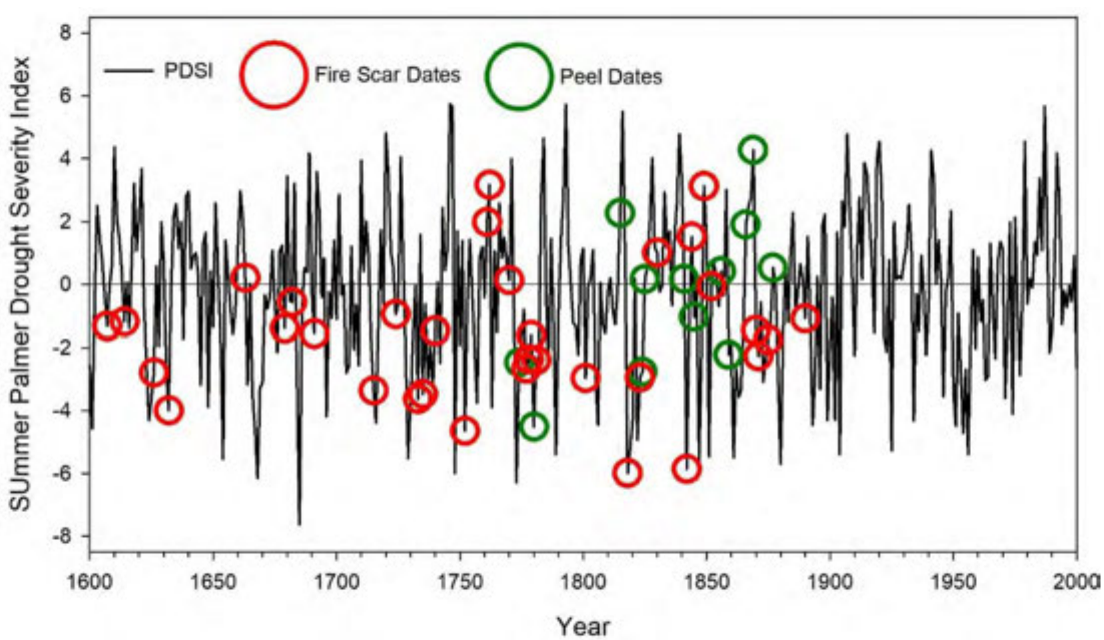


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Figure A5. Map of northern, NM showing relative locations of Warm Springs, El Valle, Chimayo Canyon, Escondido Canyon, Jemez, and Philmont peeled tree collections.

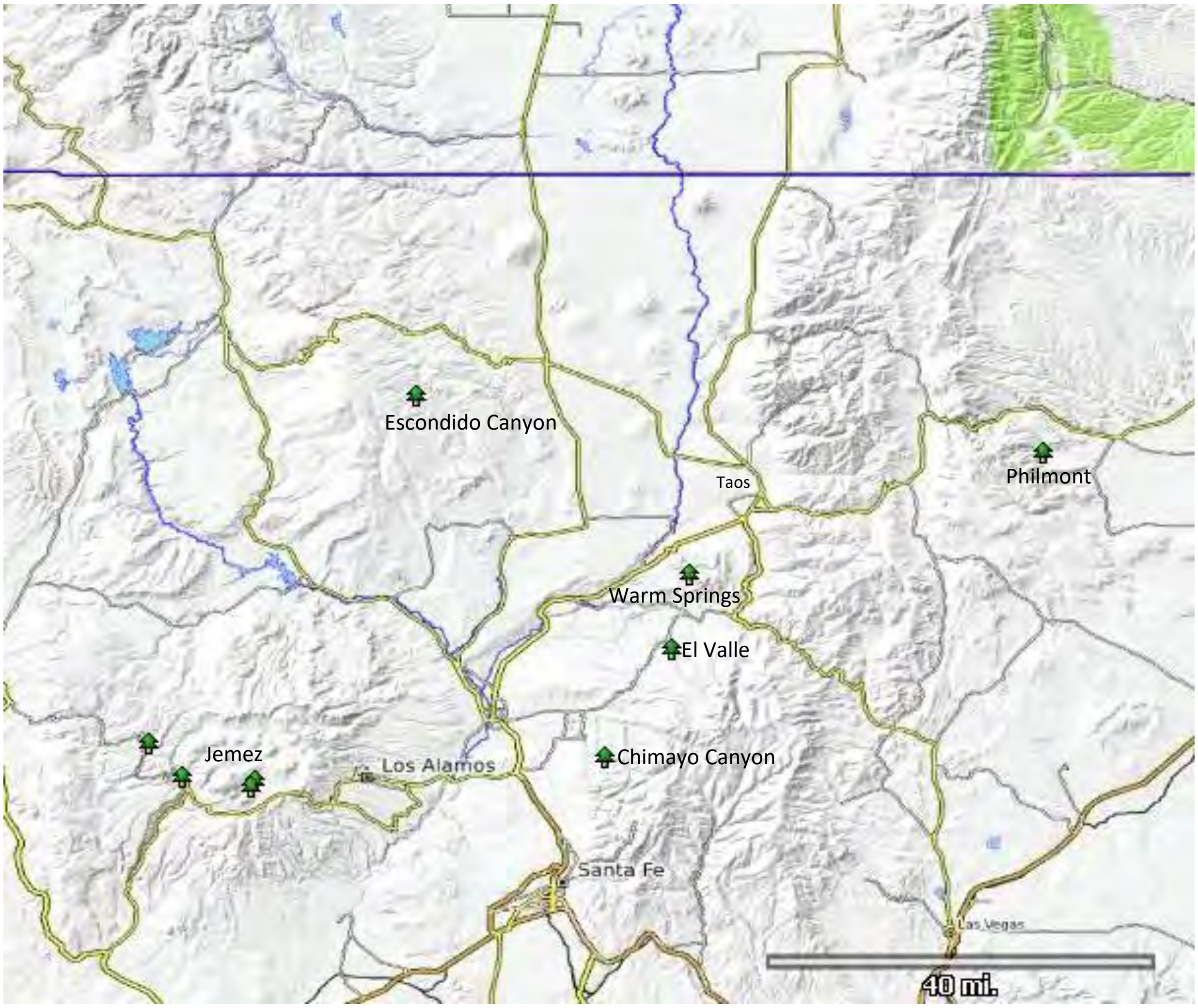
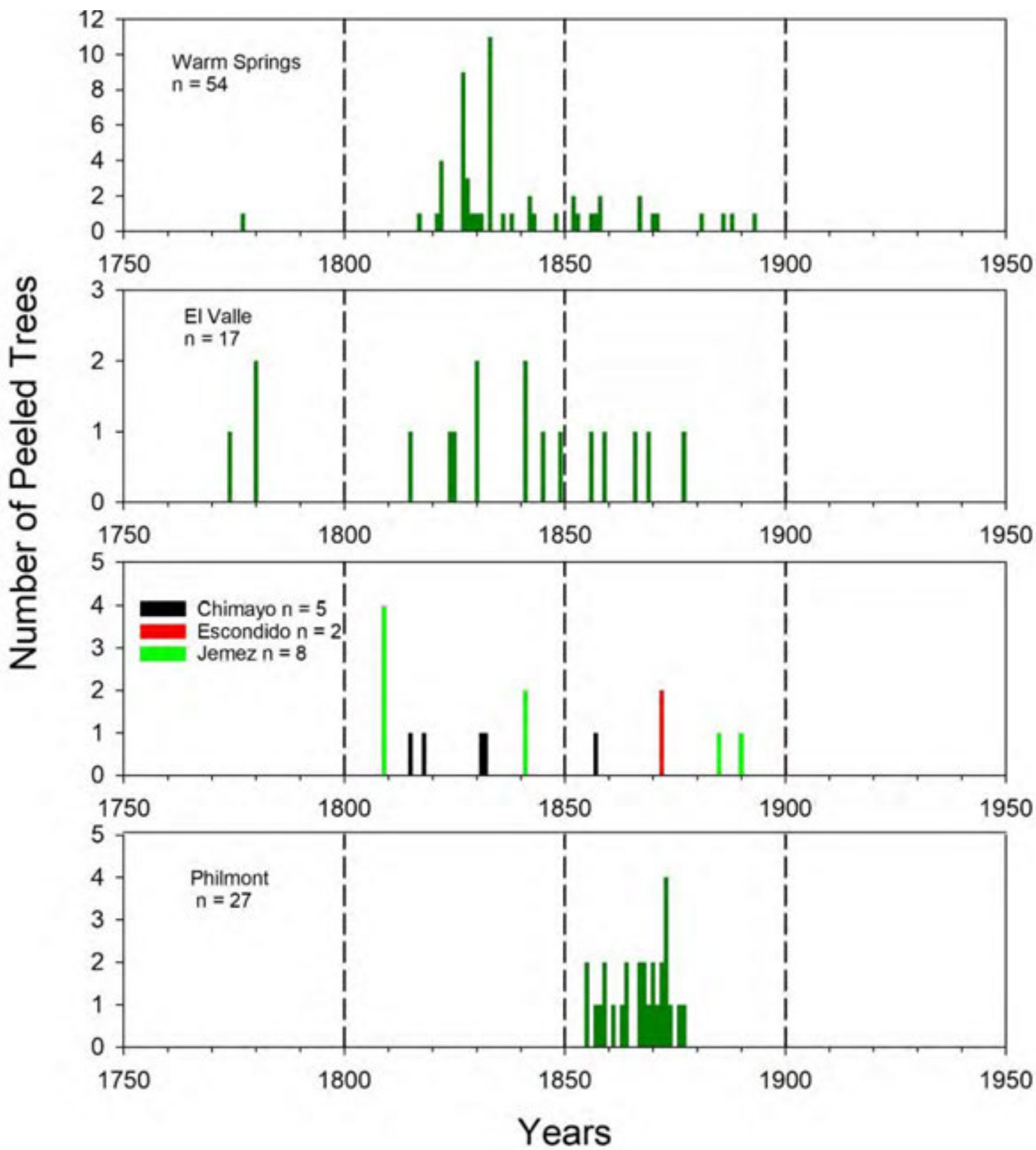


Figure A6. Comparison of peeled tree dates at Warm Springs, El Valle, Chimayo Canyon, Escondido Canyon, Jemez, and Philmont. The general pattern of peel dates across the region suggests the following potential narrative: (1) Some earlier conflicts and hard times prior to 1781 (and before the treaty with Comanches) may be associated with earliest peelings in 1770s-80; (2) increasing Spanish and Euro-American conflicts with Jicarilla Apaches in the Rio Grande Valley and tributaries in northern NM from 1820s through 1850s may have been associated the clustering of peeling date during this period; (3) the 1850s conflicts, reached a boil in 1854 with the Battle of Cieneguilla, and multiple subsequent skirmishes and battles between the US Army and Jicarilla Apaches. Taylor's (1969 historical review of

Carelton's campaign with Kit Carson as a guide suggests that the Jicarillas (at least one band) was chased into northeastern NM in late spring of 1854. Possibly the peeling dates commencing in 1855 at the Philmont site and continuing until just before the establishment of the Jicarilla reservation in northwestern NM in 1887 may be associated with presence of this band of Jicarillas, which may have included some of the same people that peeled trees at Warm Springs in earlier years.



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Appendix A, for report: Peeled Ponderosa Pine Trees at the Warm Springs, Battle of Cieneguilla Site, New Mexico, T.W. Swetnam, June 18, 2017