Larson Forest Restoration Project Historic Range of Variation (HRV Reference Conditions) Assessment Report

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Prepared for:
Apache-Sitgreaves National Forests

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I. Introduction

The Larson Forest Restoration Project (Larson Project) is located on the Apache-Sitgreaves National Forests (ASNF), Black Mesa Ranger District. The project covers a landscape area of approximately 30,000 acres, dominated primarily by ponderosa pine (*Pinus ponderosa*), with some dry mixed-conifer on the north facing slopes and an increase in alligator juniper (*Juniperus deppeana*) component on the dryer sites in the north portion of the project.

The ASNF asked the Ecological Restoration Institute (ERI) to help collect site-specific historical ecological data for the Larson Project area to establish site-specific reference conditions (forest conditions that were in place 130–140 years ago when frequent fire was still a dominant component of the ecological system). These reference conditions would be used by the interdisciplinary team (IDT) as a point of reference for forest restoration for project planning. To meet this need, ERI worked with the Black Mesa Ranger District staff to identify areas where data would be collected to establish reference conditions. ERI placed 66 individual plots within the project area (see Figure 2 below). The entire plot data collection was completed through a rapid assessment process and is documented in an attached report (Reference Material, Appendix C).

This data was used to establish forested reference conditions that can serve as an important guide for future management. The importance of these data is captured in Forest Service Manual (FSM) 2000 – National Forest Resource Management, Chapter 2020 – Ecological Restoration and Resilience, section 2020.6 – Principles; where it states "Apply the following guiding principles when planning and implementing restoration projects: 3. Knowledge of past and current ecosystem dynamics, current and desired conditions, climate change projections, and human uses is fundamental to planning restoration activities."

Data on other ecological conditions were not collected as part of this effort; however, some of these data, such as fire history, are available from other sources, including a recent study by ERI located approximately seven miles outside of the Larson Project on the Rim Lakes Forest Restoration Project (see references section). It is important to emphasize that reference conditions are not the same as restoration goals. Some types of reference information—like understory vegetation, wildlife and the specific climatic conditions—are not available. ERI realizes it might not be desirable to return to exact historical conditions due to current considerations for wildlife, recreation, aesthetics and other management goals that might be captured in existing planning documents. Reference conditions alone do not provide a recipe for forest management, but they can help establish restoration and management objectives, informed by historical conditions. Reference conditions can "help (1) define what the original or ecologically sustainable condition (composition, structure, process, function) was compared to the present; (2) determine what factors caused degradation (or departure from historic conditions); (3) define what needs to be done to restore the ecosystem; and (4) develop criteria for measuring success of restoration treatments" (Egan and Howell 2001). In all cases, restoration treatments need to be site-specific. But area-specific reference conditions can be a particularly powerful tool when multiple lines of evidence are used to create a more complete picture than one type of evidence alone.

The location, presence or absence, and species composition of stumps, snags, downed logs, and old trees are reference conditions that provide a degree of unequivocal evidence of historical forest structure. In southwestern ponderosa pine ecosystems, it has been repeatedly demonstrated that frequent, low intensity fires were primarily responsible for the maintenance of sustainable ecosystem conditions during historical (pre-settlement) times (Covington and Moore 1994). Proposed project treatments would rely on an understanding of forest reference conditions, or conditions known to be within the range of healthy ecosystem variability, in order to guide ecosystems back to resilient conditions where forest structure and functions such as low intensity fire are maintained over time.

The photo below shows one example of historic structure encountered within the project area.

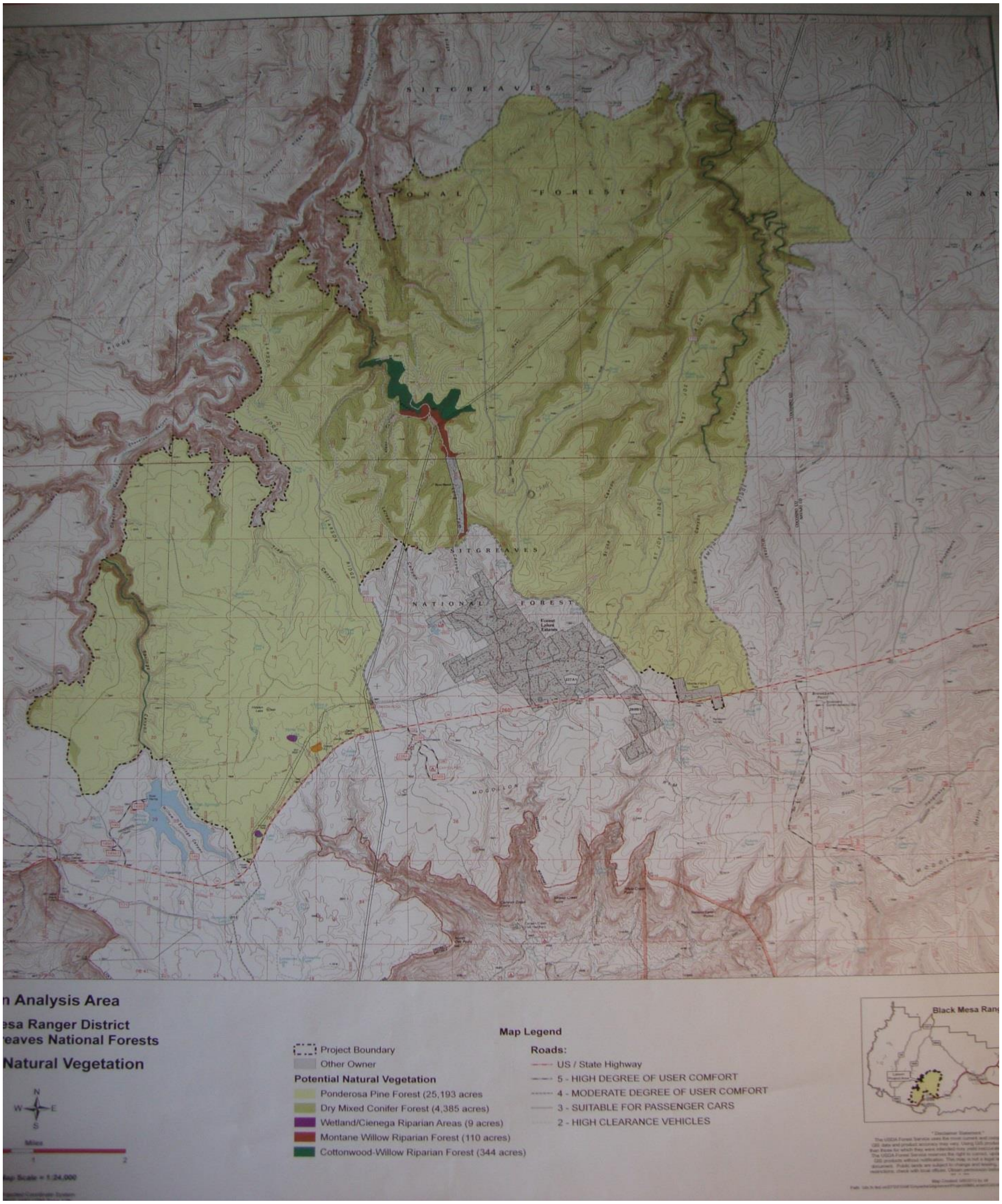

Figure 1. Larson Project Area

II. Methods

A series of 80 plots were randomly selected, from a grid of points, within the project areas with emphasis on the flatter terrain where management activities are more likely to occur (Figure 2). From these 80 plots, 66 plots were located and established in the field. Plots were an acre in size and were laid out in a square pattern (209' x 209'). The northwest corner of each plot was located with a handheld GPS unit and was marked as the plot point with re-bar, unless otherwise indicated. Within each plot, reference data were collected to establish the number of trees per acre that occupied the site prior to the disruption of the frequent fire regime that is believed to have historically dominated and shaped this area ecologically. A summary of the evidence used is shown in Chart 1. Utilizing historic fire regime research, the disruption of the fire regime in this area was determined to be 1880. This date was established from the preliminary data associated with an ERI fire study that was done at Rim Lakes; a preliminary chart of that data is shown in Appendix D.

To reconstruct frequent fire stand densities, physical remains of old, dead trees (snags, stumps, downed logs, and stump holes) were located within the plots. Living trees in the plots were examined to determine if they germinated prior to the disruption of the frequent fire regime. The process for determining live trees, associated with the frequent fire ecosystem, involved establishing a minimum age for these trees. Based on a review of previous fire history studies, it was determined that the minimum age was 133 years (trees that had germinated in 1880 or earlier). We then took increment cores from trees on-site to establish a diameter size that we estimated would represent that minimum age. We cored old ponderosa pine and alligator juniper trees at breast height (DBH). To account for diameter variation that might occur due to elevation, aspect, or other site conditions, we also cored a few trees at some of the plots to determine an appropriate diameter at breast height (DBH) for a 133-year-old tree, for each species. All live trees with a DBH greater than that for a 133-year-old tree that possessed old-tree characteristics (Table 1) were counted as live trees associated with a frequent fire ecological system. We used an eighteen inch diameter for ponderosa pine trees and an eight inch diameter cut off for alligator juniper trees, if the trees showed old tree characteristics. These live, frequent fire system trees and tree evidences were tallied by species and density.

In some previous studies, questions have been raised about the ability to accurately identify all the historical evidence with this rapid assessment reconstruction process. In a paper by Huffman et al. titled "Ponderosa Pine Forest Reconstruction: Comparisons with Historical Data," (2001), the authors determined that forest structures are readily identified in the field after 90-plus years. In this study, missed trees resulted in an underestimate of about 5.7% (about 1.7 trees per 30 trees). (See the attached paper on physical evidence used to establish reference conditions.)

In addition to collecting data on tree reference conditions (trees per acre and species), photos were taken at each plot to provide information on current forest structure, composition, and condition (ground vegetation and downed woody material). At each plot we collected data on basal area (BA), presence or absence of dwarf mistletoe, estimated canopy cover (%), and noted general observations on historical stand structure and plot conditions. We did not collect specific data on these characteristics — trees per acre, tree heights, and tree size distribution, downed woody material, soils, or understory vegetation. Additionally, we did not attempt to physically reconstruct the spatial arrangement of trees. We did reference the Terrestrial Ecosystem Unit (TES) using the write-up of the TES of the ASNF (USDA–FS 1986).

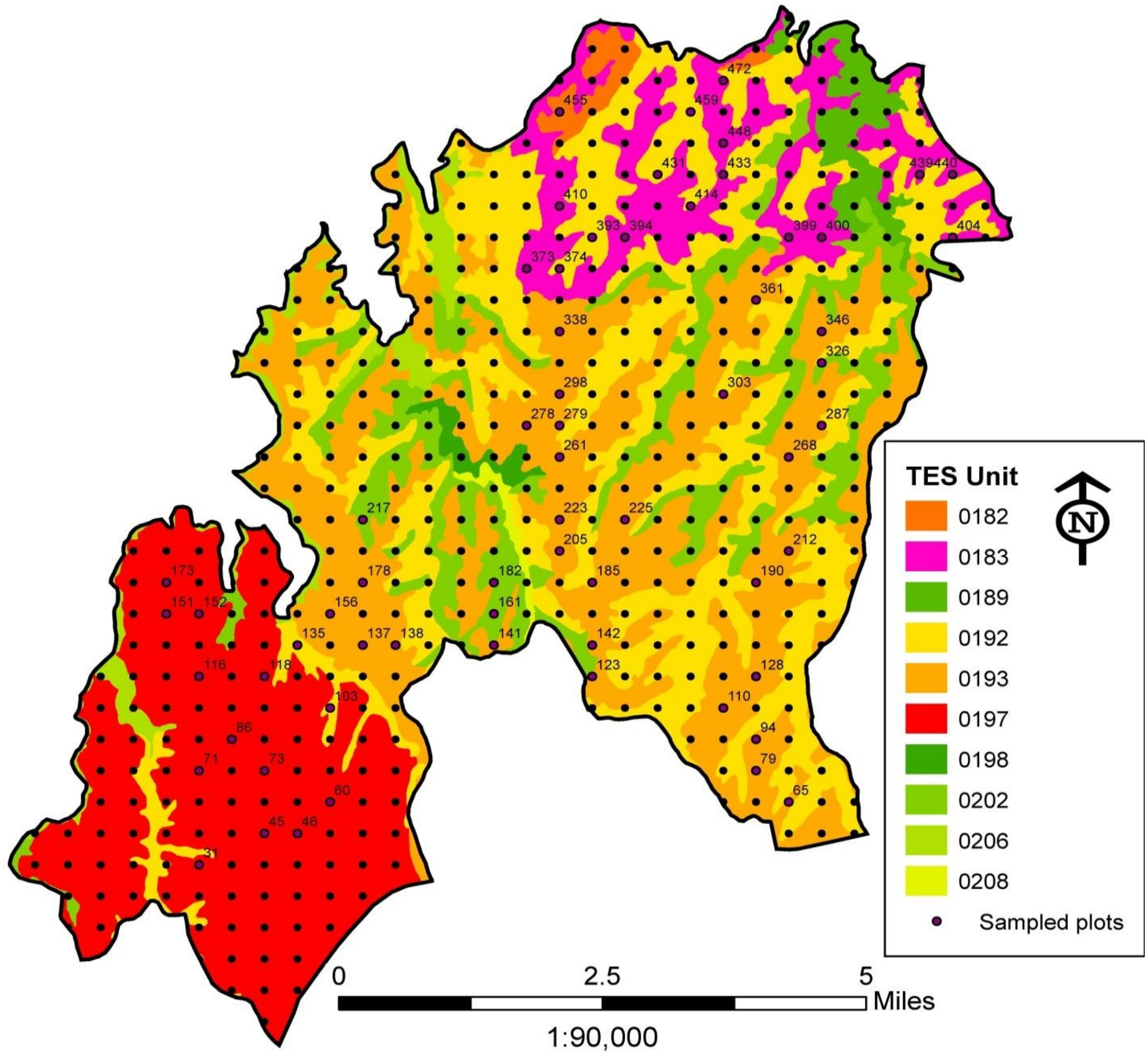

Figure 2. Terrestrial Ecosystem System (TES) mapping units, systematic grid of potential sample plots and selected plot locations of the Larson project.

III. Results

Tree Densities and Species Composition

The individual plot sheets and associated photos are attached as a separate document (Appendix C). The number of evidences associated with historical frequent fire conditions (or “1880 trees”) and the species of those evidences are summarized in the two following figures and table (Figure 3, Figure 4, and Table 1).

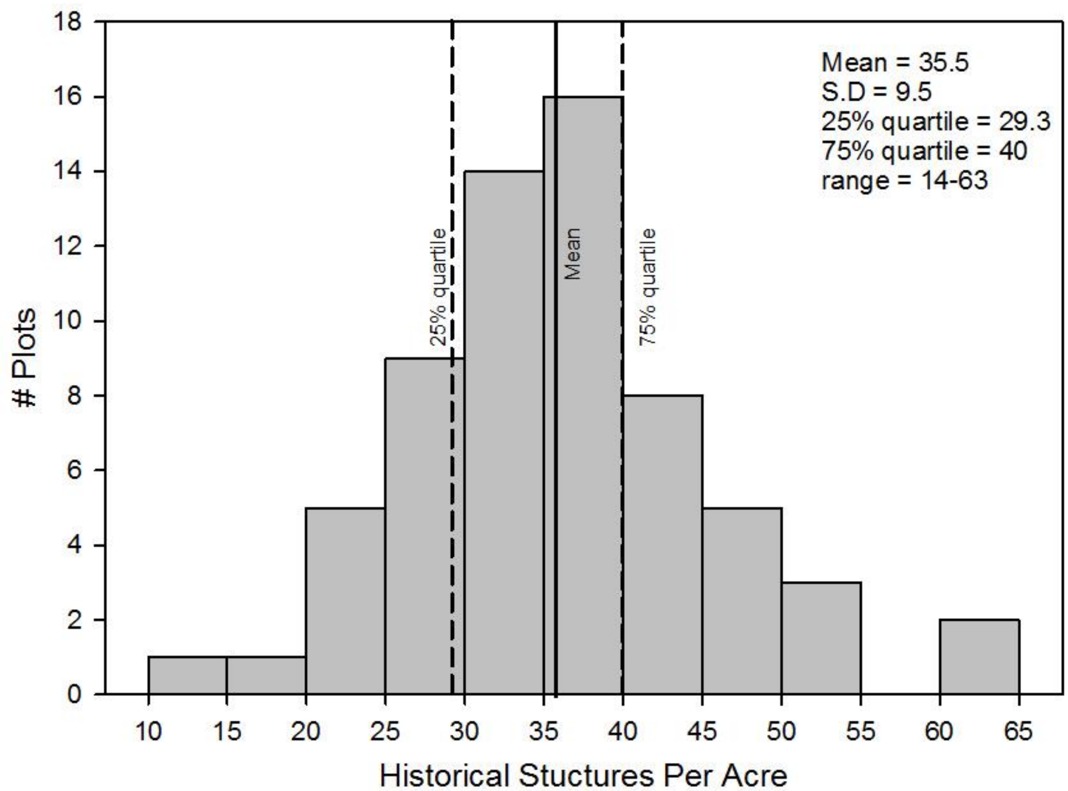

Figure 3. The X axis shows the number of historical structures per acre, which is the same as the number of evidences recorded per plot. The Y axis shows the total number of plots that recorded those numbers of historical structures.

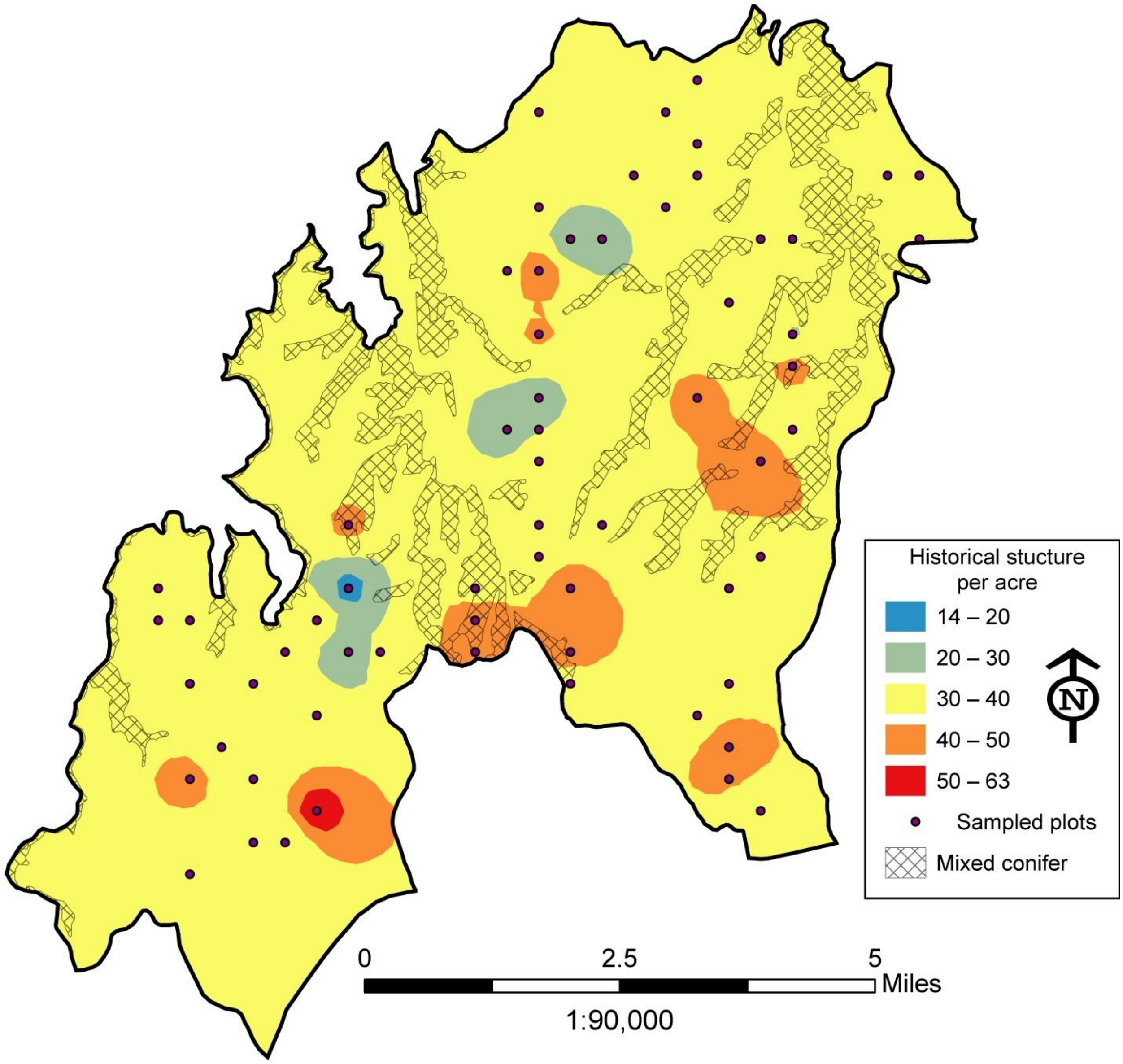

Figure 4. This map displays the historical structure (trees per acre) across the project area, based on the plot data. Historically the majority of the project area fell into the 30–40 TPA range, and there is not a real dramatic density difference for one part of the project area vs. another. We did note that groups tended to generally be larger (more trees per group) in the south end of the project area. Note some areas on the map had limited samples and the accuracy of the interpolation is likely to be lower than areas where the plots were clustered.

Table 1. Displays plot data by TES Unit within the project area. (There was 1 plot in TES unit 182.)

TES units	183	192	193	197	202
Physical Characteristics					
Elevation (ft)	7045-7361	7022-7538	7262-7598	7537-7667	7197-7497
# plots	10	10	28	13	4
Acres within project boundary	2496	7605	8212	6454	3194
Tree/acre					
Evidence Range	22-36	20-51	14-53	23-63	37-45
Evidence Avg. (SD)	30.9 (5.1)	36.7 (8.1)	35.1 (9.3)	36.8 (13.9)	42.3 (3.6)
PIPO:QUGA:JUDE (%)	95:1:4	95:3:2	100:0:0	99:1:0	100:0:0
Live trees (%)	29	34	29	35	31
Snags (%)	4	3	5	4	2
Logs (%)	6	14	8	8	10
Cut stumps (%)	61	50	56	48	57
Other (%)	0	0	2	5	0

In summary, within the 66 plots we sampled, trees per acre (TPA) ranged from a low of 14 to a high of 63. The overall average for the areas sampled was around 35 TPA. The historic tree densities were generally much lower than the current tree densities found across the project area.

Based on the data we collected, we did not see a significant difference between the TES units (shown in Figure 2) and historical tree densities, in the range of trees per acre (Table 1). The average historical densities were slightly higher in TES unit 202, and slightly less in TES unit 183, but within all TES units there were plots with similar densities.

In the areas we sampled, the bulk of the historic trees (trees that were in place prior to 1880) were ponderosa pine with some alligator juniper and Gambel oak (*Quercus gambellii*) found in the north end of the project. The project area has some dry mixed conifer located on north aspects in the drainages that bisect the project area. We found very little aspen (*Populus tremuloides*) throughout the project. What aspen we did find was more in the southern portion of the project area, and being heavily impacted by ungulate use. Some of the aspen stands have been fenced, but the exclosures were in need of repair. We did not find extensive evidence of aspen within the project and we did not tally any aspen in our plots that were associated with the frequent fire time period. It appears that aspen was not historically widespread. However, it is likely that historical frequent fire conditions were more beneficial to aspen development than current conditions. It is likely that restoration treatments especially the re-introduction of fire to the landscape will promote aspen regeneration in some areas.

IV. Fire History

We did not collect fire scar data from the project area, so we do not have project specific fire history data. We did evaluate fire history studies conducted in Arizona at similar elevation and in similar forest types. In the summer of 2011, the ERI collected fire scar and other stand data in a mixed conifer forest on the Black Mesa Ranger District of the Apache-Sitgreaves National Forest (Rim Lakes Forest Restoration Project area). The preliminary results of the fire history reconstruction portion of this study indicated some interesting aspects of the historic frequent fire regime for that area. Since the Larson project is located just 7–8 miles from the study area, it is likely that the historical fire regime within the Larson Project area was similar to the research site.

Some of the key preliminary findings from that study that can be applied to the Larson Project area are:

- Fire exclusion at the site occurred in the late 1870s, which coincides with Euro-American settlement in this region.
- Fire scares recorded in tree rings showed that frequent low-severity, spreading surface fires were prevalent for at least 250 years prior to the late 1800s. Fires at this site burned at a mean interval of around two years, with intervals ranging from about two to eight years.
- Fires not only corresponded to region-wide drought years, they also occurred in other years when local fuels conditions allowed surface fires to spread.
- The forest at the site is currently susceptible to high severity, stand-replacing wildfire as a result of the increased tree densities. Stand conditions today are outside the natural range of variability and have decreased resilience.

In summary there is evidence to conclude the Larson project area was part of a frequent fire ecological system where surface fire burned across the entire landscape on a frequent (1–10) year interval.

V. Current Stand Conditions

Quantitative data was not collected on current stand conditions (current tree densities, heights, diameters, regeneration, species composition, etc.) Comments were made at each plot to provide a general qualitative assessment. Current stand conditions can be summarized from the forest inventory data the district has. Field Notes, observations and estimations, were made at each plot and can be found in the Field Notes Summary document (Appendix C).

In general, current stands conditions were estimated to range from 250 to more than 2,500 TPA, with all diameter classes represented through multiple age cohorts. In addition to a significantly higher density of trees, we did not notice a shift in the species composition within the sample plots. We also observed that in the dry mixed conifer stands there was a shift toward more shade tolerant species within the younger trees and regeneration. Similar to what has been documented for ponderosa pine forest vegetation dynamics in the southwest (Arnold 1950, Laughlin et al. 2005, 2011, Moore and Deiter 1992), the current stand densities have been associated with a general encroachment of open areas by tree species and an overall reduction in understory vegetation (grasses, forbs, and shrubs). We observed species richness to be low on all plots. Increased shading from dense regeneration within the project has also reduced cover of understory forb and shrub layers that provide important food and hiding cover, compared to what we know about historical conditions (Vankat 2013). Another effect of the high density of trees, that we observed, is the presence of an average 1–2-inch litter layer (sometimes this layer exceeds 5–6 inches) that virtually eliminates any current problems with soil erosion; however, it also precludes the development of robust ground vegetation (e.g., Arnold 1950; Cooper 1960; Korb and Springer 2003). We also noted a general increase in the amount of downed dead woody material, compared to what we know existed with frequent fire forest conditions.

The most significant condition of the project area is the current tree density, which, in conjunction with the associated increased fuel loading, represents ecosystem health concerns and vulnerability to severe insect outbreaks and destructive, high intensity crown fire. These conditions, if left untreated, will continue to degrade, ultimately resulting in a potentially catastrophic consequence.

There are 10 to 80 times as many trees across the landscape than we estimate were present in the historic, frequent-fire regime period. The age class diversity has shifted due to dramatic increase in the number of younger trees. Tree groups have changed in that there are larger dense pockets of younger trees today and the separation of the tree groups by open non tree areas does not generally exist in the project area. Historically there were uneven aged tree groups, today there are even aged tree groups as well as dense tree groups that have several cohorts. Canopy cover was estimated to be in the 60–70 percent cover range for the majority of the sample sites. This is an indication of the large number of trees and lack of open areas. The average basal area (BA) was 120 square feet in the sampled plots, but we encountered areas where the BA was much higher. Our observations of what the historic structure looked like, and how current conditions vary from frequent fire conditions, are captured in a series of photos (Appendix E).

Current conditions are very likely due to the disruption of the historic frequent fire regime during the last 130–140 years. As widely observed in forests across the Southwest, this has likely resulted in the dramatic increase in the number of trees per acre, a substantial decrease in the abundance and species of understory vegetation, and a loss of plant vigor and structure. The lack of frequent fire has also lowered the canopy base height, promoting the increased potential for crown fire development. Historically, much of the project area likely had a higher percentage of ground cover dedicated to grasses along with other understory species, including legumes and shrubs. As the tree densities increased, understory plant cover declined. Prior to the exclusion of fire the low density of trees within the interspaces promoted much higher forage production. The TES write up estimated that this range went from a low of 2,000 pounds per acre (air/dry) to a high of 3,500 pounds per acre (air/dry) within the terrestrial ecosystem map units (TESU) surveyed. We did not encounter a lot of evidence of historic aspen stands so we cannot make a determination of the historic extent it had.

VI. Considerations and Possible Treatments

The intent of this assessment is not to provide specific management direction, but rather to identify historic conditions as an informational tool to consider in the strategic analysis of the Larson Project. Based on what we found with the historical conditions, we recommend the following considerations:

1. The attached historical (frequent fire) stand data could be considered as a reference in determining the desired future conditions and as a baseline for monitoring. This historical range of variability data can be used as a reference in establishing the limits of acceptable change in the project area's ecosystem patterns and processes. Determining the departure of current conditions from the historical range of variability can be helpful in assessing and communicating the risks and probability of change and the inputs required to resist that change. Alternative future conditions can also be evaluated relative to the historical range of variability in ecosystem components and processes.
2. The option of returning to pre-settlement conditions across the entire landscape is unrealistic. However, to address current fire and forest health concerns, it would be reasonable to consider restoring a significant amount of the historical composition, spatial structure, and age distribution within the tree-dominated landscape. The descriptions identified in the Region 3 Desired Conditions Framework for ponderosa pine and dry mixed conifer restoration provides an appropriate set of objectives to accomplish as part of restoring the project area.
3. Consider reducing tree density closer to historical conditions in order to reduce fire, insect, and disease risks, and to improve overall ecosystem health and resiliency. If the historical average density of 25–40 trees per acre is too open for other project objectives, then adjust accordingly (e.g., adjust to 2–3 times the historical density); but keep in mind; the historical conditions as they relate to climate change (developing resiliency), soil type, re-establishing a more frequent fire regime, allowing fire to play a more natural role in the ecosystem, and the ability to re-enter the stands. The creation of adequate openings and interspaces will be critical to the establishment of understory vegetation that will allow managers to use fire as a maintenance/management tool and expand ecological benefits of the sites by improving habitats, food webs, nutrient cycling, etc. Regardless of the historic tree group configurations we encountered, the one constant throughout the project area was the presence of openings between these tree groups. Open areas were a key element of a properly functioning frequent fire ponderosa pine ecosystem in this area. The re-establishment of openings and their associated diverse ground vegetation will also benefit the wildlife community.
4. Consider the re-introduction of frequent fire as a management tool for the project area. It will be essential to develop a strategy for using fire as a management tool to meet project objectives across the project area. If openings are created and tree densities are reduced, there will be rapid re-establishment and growth of conifer regeneration, juniper, oak and other shrub species. Fire or some other form of treatment (mechanical) will be needed on a frequent basis to eliminate a return to current conditions and to allow grasses and forbs to become established in the open areas. The re-establishment of a frequent fire program will help reduce the downed woody material, establish and maintain the open areas and diverse ground vegetation, and maintain forest resiliency. It will raise crown base height, mitigate the establishment of dense pockets of regeneration, and minimize large fire impacts. There will also be a need to monitor noxious weed invasion and then utilize fire treatments accordingly. Although we did not encounter much aspen within the project area, the application of more frequent fire to the landscape should benefit the re-establishment of aspen in those areas where remnants exists.
5. Consider the possible adverse effects of incorporating a diameter cap on the ability to meet restoration goals given the current stand conditions. The need to re-establish groups and openings, restore seeps, springs, and riparian areas and to manage encroached

grasslands are critical goals that might not be adequately met with a diameter cap. Arbitrary diameter caps can have unintended consequences such as interfering with the restoration of herbaceous openings and more natural spatial distribution of clumps of trees important for wildlife habitat and forest health, also where unnaturally dense stands of larger post-settlement trees predominate, caps can limit fuel reduction and therefore limit the re-establishment of surface fire (Abella et al. 2006, Sanchez-Meador 2009). Utilizing a diameter cap can eliminate age groups from an existing stand (thinning from below), and its use trends toward even aged management (Triepke et al. 2011).

6. Promote the development of uneven aged tree groups. The existing stand conditions with multiple cohorts of pine regeneration provide an excellent opportunity to develop uneven aged tree groups. This recommendation along with those above will have positive effects on habitat improvement by providing more habitat diversity, structural variability, and opportunities for the expansion of food webs.

VII. Reference Material

Appendices

A. Table 1 – Old Tree Characteristics

In addition to DBH, we used the following characteristics to help us establish the pre-settlement trees in each plot.

Crown Shape: Transitional trees (trees that are trending toward old age; 150-200 years) have an ovoid shape—flattened top, full and rounded crowns. Old trees (>200 years) are flattened on the top, “bonsai” shape, sparse and open, maybe lopsided.

Live Crown Ratio: Transitional trees have moderate live crown ratio; perhaps half the trunk, beginning to self-prune. Old trees have small live crown ratio; often fire-pruned.

Branches: Transitional trees have dying fine branches in the interior of the crown, longer branches thickening. Old trees have few, but large branches.

Trunk shape: Transitional trees are beginning to loose taper. Old trees are columnar.

Bark: Transitional trees have orange or gray flakes with dark edges, shallow fissures, becoming smoother. Old trees have smooth, small flakes, pale orange or gray.

Likely Injuries: Transitional trees have relatively few injuries; possibly healed or mostly healed fire scars, lightning scars, and mistletoe. Old trees have fire scars, dead tops, broken branches, lightning scars, rot, burls, and exposed roots.

B. Summary Spreadsheet of Plot Data.

The following spreadsheet displays the density and type of historic evidences found on each plot. The evidences are coded as follows: L = live tree, C = cut stump, S = snag, LG = log, and SH is a stump hole. Plot “Y” is the demo plot that is located near the FR99 and FR179 road junction on the South end of the project. Plot X is a randomly selected plot done in place of plot 76.

Spreadsheet: Larson Project

Plot #	TES Unit	PIPO:L	PIPO:C	PIPO:S	PIPO:LG	PIPO:SH	QUGA:L	QUGA:C	QUGA:S	QUGA:LG	JUDE:L	Total
455	182	8	22	1	5	1						37
373	183	15	17	1							2	35
394	183	4	13		3						2	22
399	183	5	13	1	1						3	23
400	183	1	29	2	1							33
404	183		30	1								31
410	183	19	12		2						2	35
433	183	10	17	3			2	1				33
439	183	9	25		2							36
440	183	2	16		9							27
448	183	8	17	3	1		1				4	34
118	192	16	11	2	9							38
103	192	10	18	1	6							35
135	192	10	14		8							32
303	192		40	1	2							43
361	192	14	16		2							32
374	192	15	29	4	1		2					51
393	192	1	12		6		1					20
459	192	6	14	1	12		2	1				36
414	192	17	16		2						5	40
431	192	19	11	1	3		5		1			40
65	193	5	19	2	2							28
79	193	2	30	1	1	7						41
94	193	12	31	4	6							53
110	193	12	15	1		1						29
123	193		25	1	4							30
128	193	9	15	3	4							31
137	193	9		7	2							18
138	193	9	18	3	2	2						34
141	193	12	31		3	1						47
142	193	12	21	4	8	2						47
156	193	15	14	2	2	6						39
178	193	2	12									14
185	193	22	19	1	3							45
190	193	9	28	2	1							40
205	193	20	12	2	2							36
212	193		31	2	5							38
223	193	16	22		1							39
225	193	19	12	1	2							34
261	193	12	16	4	4							36
268	193	32	16		2							50
278	193	3	18		2							23
279	193	12	17	1								30

Plot #	TES Unit	PIPO:L	PIPO:C	PIPO:S	PIPO:LG	PIPO:SH	QUGA:L	QUGA:C	QUGA:S	QUGA:LG	JUDE:L	Total
283	193	This plot was in an old sheep ground so no data was collected.										0
287	193	7	22		1							30
298	193	9	11	3	3							26
338	193	9	24	1	8							42
346	193		28	1								29
Plot Y	193	10	19	3	6							38
31	197	9	18		6							33
45	197	16	19			4						39
46	197	15	5			5						25
60	197	26	13	1	21	1						62
71	197	8	32	5	2							47
73	197	10	14		1	2						27
86	197	10	11	2	1	3						27
116	197	10	18	3		2						33
151	197	19	38	2	4							63
152	197	4	14			5						23
173	197	12	8	1	2	2						25
472	197	12	20	3			2					37
Plot X	197	12	8	3	1	1						25
161	202	10	34		1							45
182	202	12	20		5							37
217	202	10	25		8							43
326	202	20	18	3	3							44

C. Field Notes Summary (Appendix C, attached CD).

D. Fire History Chart from Rim Lakes Project (Chart 1, page 17).

E. Document on Structure Photos and Current Conditions (Appendix E. attached).

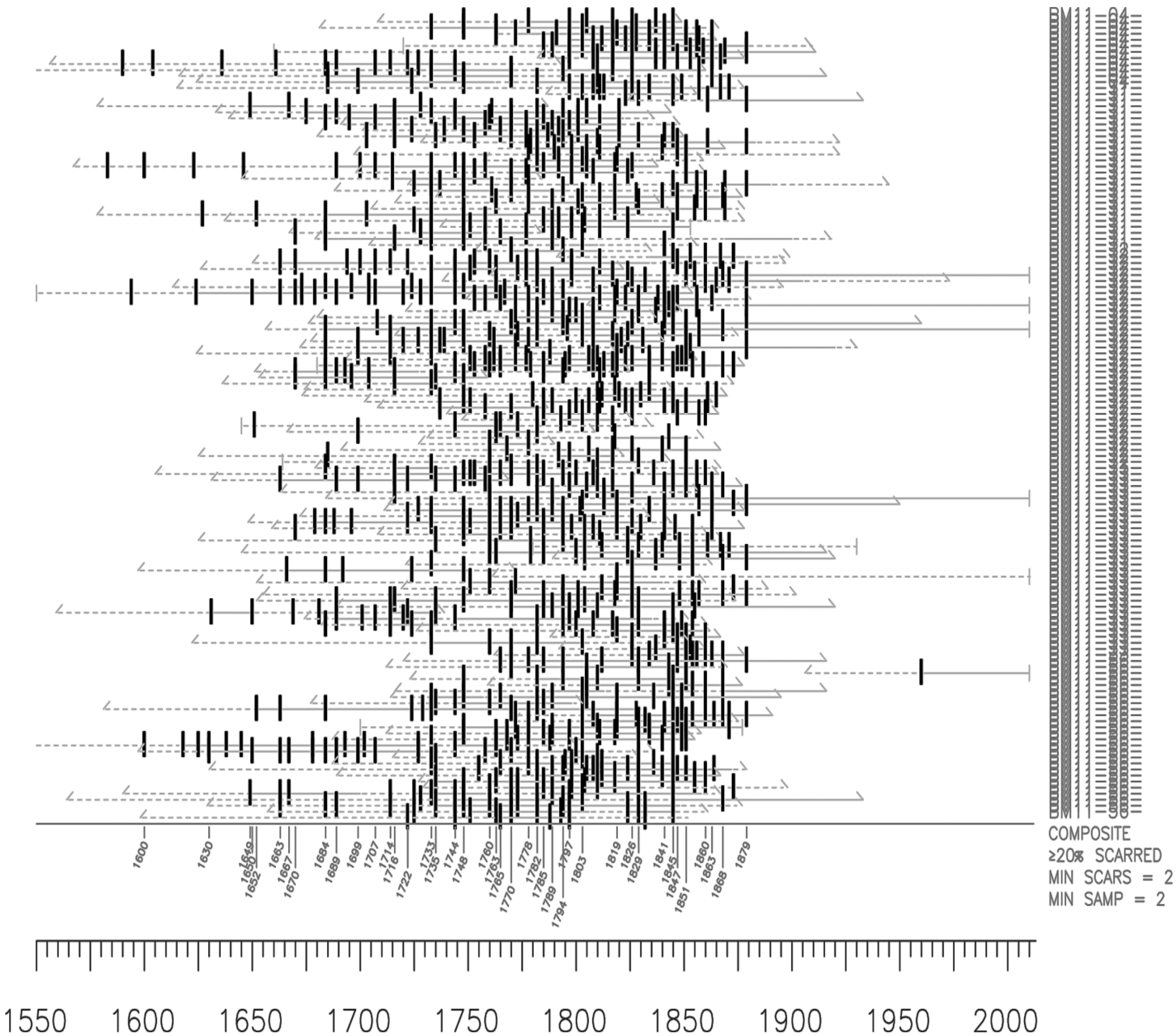

Chart 1. The above chart shows the preliminary presettlement fire history data for a Black Mesa mixed-conifer study site. Horizontal lines are wood samples from individual trees. Vertical tick marks are fire scars. Around 1880 there was an abrupt halt in frequent fire occurrences.

VIII. References

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In addition to the information in this report, we have added some reference material that would be good information for possible future management activities.

Ponderosa Pine Restoration

The following references are good information sources for restoration management.

ERI Working Papers, which can be located at http://nau.edu/ERI/

ERI Working Paper 7: Establishing Reference Conditions for Southwestern Ponderosa Pine Forests, April 2004.

ERI Working Paper 9: Restoration of Ponderosa Pine Forests to Presettlement Conditions, February 2005.

ERI Working Paper 22: Restoring Spatial Pattern to Southwestern Ponderosa Pine Forests, June 2008.

Management of Gambel Oak

Abella, S.R. 2008. Gambel oak growth forms: Management opportunities for increasing ecosystem diversity. Research Note. RMRS-RN-37. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Abella, S.R. and P.Z. Fulé. 2008. Fire effects on Gambel oak in Southwestern ponderosa pine-oak Forests. Research Note. RMRS-RN-34. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Management of Aspen

www.aspensite.org is a great place to get information.

Climate Change

Region 3 Climate Change Paper:
http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5181242.pdf