Ecological Restoration Institute

Fact Sheet: Historical Forest Structural Characteristics Review *August 2011*

Compilation of Historical Forest Structural Characteristics across the Southern Colorado Plateau

National forest planners now endorse the ecological restoration of forests adapted to frequent surface fires as a way to reduce wildfire hazards and reestablish forest health (U.S. Forest Service Planning Rule, February 10, 2011). An essential step in designing successful ecological restoration treatments for such forests requires understanding the ecological environment that existed when a forest was still resilient and healthy. These past environmental settings are referred to as reference conditions (Covington et al. 1997, Moore et al. 1999, Swetnam et al. 1999). Reference conditions help identify what a forest looked like (e.g., trees per acre, ages of trees, species composition, amount of understory) and how it functioned (e.g., surface fire frequency, crown fire frequency, soil building) in the past. Reference conditions are determined by studying various sources of information including old maps and photographs, pollen studies, tree-ring dating, original land surveys, and field observations (Egan and Howell 2001, Friederici 2004). Reference conditions help planners and restorationists determine site potential, set restoration goals, and, ultimately, evaluate the success of restoration efforts (Moore et al. 1999).

This ERI fact sheet provides pre-EuroAmerican settlement overstory structural reference conditions (i.e., tree density and basal area) for pinyon-juniper, ponderosa pine, ponderosa pine-oak, aspen, and mixed conifer forests across the southern Colorado Plateau. It is intended to help managers visualize and describe what the forest structure looked like before frequent surface fires were disrupted in the areas they now manage. This reference information should also serve as an aid in making informed decisions that are consistent with the evolutionary range of variability associated with individual forest types. As planners and land managers develop management goals and objectives they will, of course, consider such reference conditions in the context of local ecosystem composition and function, and potential climate change.

Since reference conditions are developed from site-specific information, they are limited to the spatial extent and sample area of that study. Thus, there is no "one size fits all" set of reference conditions because ecosystems vary across landscapes and within landscapes in terms of vegetation type, soil parent material, and historical land uses. Nevertheless, dependable, locally derived information can be described as being within a range of historic or natural variation (Morgan et al. 1994). For example, in Table 1, the historic range of variation for ponderosa pine forests on basalt soils on the Coconino National Forest can be described as averaging between 15-43 trees per acre. The data in Table 1 also indicates that presettlement mixed conifer forests on basalt soils had an average range between 21-65 trees per acre on sites on the Coconino National Forest. As the data shows, other densities occurred across the Colorado Plateau depending on forest type, location, soil parent material, and elevation.

The data summaries in this fact sheet were compiled following an intensive literature review of historical structural characteristics in forests across the southern Colorado Plateau. This information was derived from either early historical inventories or forest reconstruction studies. Historical inventories were conducted between 1909 and 1952, generally by the U.S. Forest Service, to quantify stocking, growth, and mortality rates at both the individual tree and the stand level. The reconstruction studies used either standing age classes of live trees or more thorough dendrochronological analyses that included tree-ring dating both live and dead trees (Fulé et al. 1997). We find that these dendrochronological reconstructions typically produce more accurate estimates of historical forest structure than simple interpretation of standing age classes. We also used reference dates that coincide with the time of disruption of site-specific, frequent-fire regimes to reconstruct forest conditions for a given area. Presettlement structural conditions are presented by vegetation type and soil-parent material.

The majority of the studies identified in this review reported diameter at breast height (DBH) or age distributions of trees for the given reference date (Table 2). Only nine of the studies report reference information regarding the spatial patterns of trees (Table 2). The literature review identified 63 sites where either historical forest inventories or dendrochronological reconstructions were produced (Table 1). Reference information was most prevalent in ponderosa pine and pine/oak vegetation types. Mixed conifer (15%), aspen (3%), bristlecone (2%), and spruce/fir forest (3%) had significantly less reference condition information in the literature.

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Table 1. Historical forest structural characteristics of conifer forests across the southern Colorado Plateau, arranged by vegetation type and parent material. **NR = not reported. Parent material code: Ba = basalt, Ci = cinders, Gr = granitic, Li = limestone, Rh = rhyolite, Sa = sandstone, Sh = shale, Tu = tuff**

Ref #	State-management agency, site	Parent material	Avg. elev. (ft)	Trees per acre			Basal area (ft^2/acre)		
				range	avg.	se	range	avg.	se
Pinyon-juniper									
4	AZ-GCPNM-BLM, Mt. Trumbull	Ba	6353	104-261	182.5	78.5	NR	NR	NR
1	AZ-Flying M Ranch, Anderson Mesa-b	Ba	6801	NR	44.5	NR	NR	21.5	NR
1	AZ-AZ State T.L., Anderson Mesa	Li	6299	NR	100.8	NR	NR	39.5	NR
3	AZ-S. Kaibab, Tusayan-pj	Li	6690	0-567	248	10.6	NR	NR	NR
1	AZ-AZ State T.L., Anderson Mesa-s	Sa	6299	NR	49.0	NR	NR	46.2	NR
2	NM-Carson, Canjilon	Sh	7800	0-455	193.8	10.1	NR	NR	NR
Ponderosa pine									
6	AZ-Coconino, Flagstaff-c	Ci	7355	7-74	22.5	6.2	NR	NR	NR
5	AZ-Coconinio, red cinder	Ci	7631	NR	74.1	NR	NR	65.3	NR
22	AZ-Coconino, Woolsey[b]	Ba/Ci	7052	18-51	33.1	4.6	40-79	61.5	5.6
16	AZ-Coconino, Hill	Ba/Li	7382	NR	108	65.6	NR	16.1	4.4
24	AZ-A-S, Sitgreaves (max)	Ba	6300	NR	31.0	NR	NR	66.9	NR
10	AZ-A-S, Malay Gap	Ba	7200	NR	124	NR	NR	70.1	NR
12	AZ-A-S, Mineral-EB	Ba	8000	13-59	35.0	4.7	13-70	40.3	4.7
26	AZ-Coconino, Coconino (avg)[c]	Ba	6907	NR	16.0	NR	NR	38.1	NR
24	AZ-Coconino, Coconino (max)[b]	Ba	6907	NR	34.5	NR	NR	81.2	NR
11	AZ-Coconino, Gus Pearson	Ba	7300	NR	22.8	NR	NR	46.2	NR
18	AZ-Coconino, Gus Pearson	Ba	7300	NR	24	NR	NR	NR	NR
23	AZ-Coconino, Gus Pearson	Ba	7398	NR	15	NR	NR	NR	NR
7	AZ-Coconino, Flagstaff-b	Ba	7355	1-58	23.7	4.0	NR	NR	NR
8	AZ-Coconino, Chimney Spring[b]	Ba	7380	NR	42.8	NR	NR	NR	NR
20	AZ-Coconino, GPNR-6a[d]	Ba	7400	NR	21.8	NR	NR	56.6	NR
14	AZ-Coconino, Ft. Valley-EB[a]	Ba	7473	24-50	39.4	2.1	27-80	49.3	4.7
9	AZ-Coconino, San Francisco Peaks	Ba	8594	NR	24.8	2.6	NR	33.0	4.9
25	AZ-Prescott, Prescott (avg)[b]	Gr	5320	NR	27.7	NR	NR	25.5	NR
6	AZ-Coconino, Flagstaff-l	Li	7355	14-34	22.0	2.2	NR	NR	NR
15	AZ-N. Kaibab, Kaibab Plateau	Li	7500	NR	45.3	NR	NR	60.7	NR
21	AZ-N. Kaibab, Kaibab Plateau[c]	Li	7500	40-55	NR	NR	NR	NR	NR
13	AZ-N. GCNP, Little Park	Li	8705	NR	136.6	20.1	NR	57.9	23.1
27	AZ-S. Kaibab, Tusayan (avg)[c]	Li	7075	NR	10.7	NR	NR	22.1	NR
19	NM-Gila, GILA	Li	9055	NR	65.6	NR	NR	NR	NR
17	UT-ZNP, Zion	Li	7096	3-25	14.0	NR	NR	NR	NR
19	NM-Cibola, CIB	Rh	8382	47-61	54.2	6.9	NR	NR	NR
24	NM-Cibola, Zuni (max)[b]	Rh	6557	NR	22.6	NR	NR	52.8	NR
24	NM-Carson, Carson (max)[b]	Sh	6983	NR	38.4	NR	NR	79.9	NR
19	NM-Santa Fe, JEM	Tu	7825	66-112	88.8	23.2	NR	NR	NR
24	NM-Santa Fe, Jemez (max)[b]	Tu	7013	NR	35.6	NR	NR	91.2	NR
Ponderosa Pine-Oak									
29	AZ-Coconino, Bar M Canyon	Ba	7000	21-24	23.0	NR	NR	65	NR
30	AZ-Dept. of Defense, Camp Navajo	Ba	7592	NR	59.9	5.8	NR	56.2	6.1
40	AZ-GCPNM-BLM, Mt. Trumbull	Ba	6970	0-220	39.2	3.9	0-143	41.6	4.1
43	AZ-GCPNM-BLM, Mt. Trumbull-EB	Ba	7141	14-33	24.7	5.1	20-60	32.2	11.7
41	AZ-GCPNM-BLM, Mt. Logan-b	Ba	7483	NR	38.3	5.8	NR	46.2	7.8
36	AZ-GCPNM-BLM, Mt. Trumbull Wild	Ba	7740	NR	25.2	3.5	NR	38.8	6.1
42	AZ-GCPNM-BLM, Mt. Logan-c	Ci	7115	34-38	29.9	6.4	60-64	60.3	9.1
39	AZ-Coconino & NPS, Walnut Canyon[e]	Li	6808	NR	29.1	NR	NR	39.2	NR
28	AZ-N. Kaibab, North Kaibab	Li	7300	NR	55.9	NR	NR	NR	NR
34	AZ-N. GCNP, Powell Plateau	Li	7533	8-262	63.6	9.4	20-337	78.0	10.9

35	AZ-N. GCNP, Rainbow Plateau	Li	7612	8-228	64.6	10.4	19-281	74.1	12.6
31	AZ-N. GCNP, Fire Point	Li	7671	16-126	61.8	61.8	28-132	89.3	9.1
32	AZ-S. Kaibab, Grandview	Li	7422	4-247	56.7	5.7	1-99	39.6	2.6
33	AZ-S. Kaibab, South Kaibab	Li	7428	8-227	58.6	12.6	14-132	54.9	6.5
38	AZ-S. Kaibab, Tusayan-EB1	Li	7840	NR	48.4	6.8	NR	60.8	10.8
37	AZ-S. GCNP, Grandview-EB2	Li	7460	NR	45.2	7.9	NR	40.5	7.9
Mixed Conifer									
50	AZ-Coconino, S. Francisco Peaks-E	Ba	8318	NR	20.9	3.4	NR	39.6	3.9
51	AZ-Coconino, S. Francisco Peaks-W	Ba	8318	NR	21.0	1.7	NR	54.0	6.1
44	AZ-Coconino, S. Francisco Peaks	Ba	9200	NR	65.1	6.8	NR	77.9	12.8
48	AZ-A-S, Blue & White Mts.[b]	Ba	8950	NR	68.7	NR	NR	84.4	NR
47	CO-San Juan, Middle Mtn.	Gr	8520	51-59	57.3	4.0	43-60	47.9	4.6
45	AZ-N. GCNP, Swamp Ridge	Li	8143	36-151	99.4	5.2	65-235	124.1	7.8
49	AZ-N. GCNP, Swamp Ridge-EB3	Li	8200	NR	93.1	8.4	NR	101.1	10.8
52	AZ-N. Kaibab, Big Park[c]	Li	8400	NR	47.6	NR	NR	34.3	NR
46	AZ-N. GCNP, Little Park	Li	8640	NR	98.3	5.8	NR	76.7	9.1
24	NM-Lincoln, Alamo (max)[b]	Li	8650	NR	46.5	NR	NR	97.9	NR
Aspen									
53	AZ-Coconino, S. Francisco Peaks	Ba	9470	NR	55.2	4.8	NR	34.5	5.0
54	AZ- N. GCNP, Little Park	Li	8800	NR	101.7	15.3	NR	47.0	7.8
Bristlecone, Spruce/Fir									
55	AZ-Coconino, S. Francisco Peaks	Ba	10863	NR	114.5	14.5	NR	118.9	16.2
56	AZ-Coconino, S. Francisco Peaks	Ba	10387	NR	106.4	16.5	NR	67.4	14.3
57	AZ-N. GCNP, Little Park	Li	8820	NR	60.6	6.0	NR	42.3	5.2

[a] Unpublished Ecological Restoration Institute information

Minimum tree DBH included in inventory = 4in.[b], 6in.[c], 9in.[d], 10in.[e]

Table 2. Descriptions of all studies identified in the literature review.

Forest type	Ref #	Reference	Area (acres)	DBH or age distribution reported?	Spatial pattern reported?	Method	Reference date
Pinyon-juniper	1	Gascho Landis & Bailey 2005	5.8	Yes-A/D	Yes	Dendro-reconstruction	1860
	2	Huffman et al. 2006	1,011	No	No	Dendro-reconstruction	1887
	3	Huffman et al. 2006	1,903	Yes-A	No	Dendro-reconstruction	1890
	4	Huffman et al. 2008	45	Yes-A	No	Dendro-reconstruction	1875
Ponderosa	5	Abella 2008	2.5	Yes-A/D	Yes	Dendro-reconstruction	1885
	6	Abella et al. 2011	30	No	Yes[b]	Standing age class	1880
	7	Abella et al. 2011	63	No	Yes[b]	Standing age class	1880
	8	Biondi et al. 1994	10	Yes/D	Yes	Historical inventories	1920
	9	Cocke et al. 2005	2,576	Yes-A	No	Dendro-reconstruction	1876
	10	Cooper 1960	27	Yes-A/D	Yes	Historical inventories	1952
	11	Covington et al. 1997[c]	11	No	Yes	Dendro-reconstruction	1876
	12	ERI, unpublished data	237	Yes-A/D	No	Dendro-reconstruction	1880
	13	Fulé et al. 2003	613	Yes-A	No	Dendro-reconstruction	1880
	14	Hurteau et al. 2010	450	Yes-D	No	Dendro-reconstruction	1876
	15	Lang and Stewart 1910	500	Yes-D	No	Historical inventories	1909
	16	Laughlin et al. 2011	8	No	No	Dendro-reconstruction	1912
	17	Madany & West 1983	51	Yes-A	No	Standing age class	1881
	18	Mast et al. 1999[c]	11	Yes-A	No	Dendro-reconstruction	1876
	19	Moore et al. 2004	2.5	Yes-A/D	No	Dendro-reconstruction	1890
	20	Pearson 1950	160	Yes-D	No	Historical inventories	1925
	21	Rasmussen 1941	2.5	No	No	Historical inventories	1929

	22	Sanchez-Meador et al. 2010a	38	Yes-D	Yes[a]	Dendro-reconstruction	1873-1874
	23	White 1985	18	Yes-A	Yes	Standing age class	1875
	24	Woolsey 1911	10	Yes-D	Yes	Historical inventories	1910
	25	Woolsey 1911	128	Yes-D	No	Historical inventories	1910
	26	Woolsey 1911	1,888	Yes-D	No	Historical inventories	1910
	27	Woolsey 1911	5,920	Yes-D	No	Historical inventories	1910
Ponderosa-oak	28	Covington & Moore 1994a	29	No	No	Dendro-reconstruction	1881
	29	Covington & Moore 1994b	43	No	No	Dendro-reconstruction	1867
	30	Fulé et al. 1997	1,730	Yes-A/D	No	Dendro-reconstruction	1883
	31	Fulé et al. 2002	334	Yes-A	No	Dendro-reconstruction	1879
	32	Fulé et al. 2002[d]	1,490	Yes-A	No	Dendro-reconstruction	1887
	33	Fulé et al. 2002	511	Yes-A	No	Dendro-reconstruction	1887
	34	Fulé et al. 2002	778	Yes-A	No	Dendro-reconstruction	1879
	35	Fulé et al. 2002	556	Yes-A	No	Dendro-reconstruction	1879
	36	Heinlein et al. 1999	445	Yes-A/D	No	Dendro-reconstruction	1870
	37	Heinlein et al. 2000[d]	81	No	No	Dendro-reconstruction	1887
	38	Heinlein et al. 2000[d]	123	No	No	Dendro-reconstruction	1887
	39	Menzel & Covington 1997	12	Yes-D	No	Dendro-reconstruction	1876
	40	Roccaforte et al. 2010[e]	2,965	Yes-D	No	Dendro-reconstruction	1870
	41	Waltz & Fulé 1998	519	Yes-A/D	No	Dendro-reconstruction	1870
	42	Waltz & Fulé 1998	247	Yes-A/D	No	Dendro-reconstruction	1870
	43	Waltz et al. 2003[e]	245	Yes-A/D	No	Dendro-reconstruction	1870
Mixed conifer	44	Cocke et al. 2005	1,565	Yes-A	No	Dendro-reconstruction	1876
	45	Fulé et al. 2002	667	Yes-A	No	Dendro-reconstruction	1879
	46	Fulé et al. 2003	1,119	Yes-A	No	Dendro-reconstruction	1880
	47	Fulé et al. 2009	474	Yes-D	No	Dendro-reconstruction	1870
	48	Greenamyre 1913	500	Yes-D	No	Historical inventories	1912
	49	Heinlein et al. 2000	103	No	No	Dendro-reconstruction	1879
	50	Heinlein et al. 2005	395	Yes-A	No	Dendro-reconstruction	1892
	51	Heinlein et al. 2005	395	Yes-A	No	Dendro-reconstruction	1876
	52	Lang and Stewart 1910	128	Yes-D	No	Historical inventories	1909
Aspen	53	Cocke et al. 2005	2,521	Yes-A	No	Dendro-reconstruction	1876
	54	Fulé et al. 2003	1,759	Yes-A	No	Dendro-reconstruction	1880
Bristlecone	55	Cocke et al. 2005	1,069	Yes-A	No	Dendro-reconstruction	1876
Spruce/fir	56	Cocke et al. 2005	817	Yes-A	No	Dendro-reconstruction	1876
	57	Fulé et al. 2003	7,067	Yes-A	No	Dendro-reconstruction	1880

[a] Information in Sanchez-Meador et al. 2011

[b] Information in Abella & Denton 2009

[c, d, e] Overlapping study area

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