USDA FOREST SERVICE

SOUTHWESTERN REGION

RECOMMENDED

OLD-GROWTH DEFINITIONS AND DESCRIPTIONS

AND

OLD-GROWTH ALLOCATION PROCEDURE

BY: SOUTHWESTERN REGION OLD-GROWTH CORE TEAM

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I. Introduction

A. National Level

The "Generic Definition and Description of Old-growth" dated October 11, 1989, (Appendix 1) is intended to affirm and articulate Regions 3's view of old-growth forests and how we plan to learn anu understand its management. Old-growth forests are defined as "**Ecosystems distinguished by old trees and related structural attributes. Old-growth encompasses the later stages of stand development that typically differ from earlier stages in a variety of characteristics which may include tree size, accumulations of large dead woody material, number of canopy layers, species composition, and ecosystem function.**"

National direction is to use this Generic Definition to serve as a framework for the development or modification of specific old-growth definitions by forest types or groupings of similar types. The specific definitions are to relate to structural components of the ecosystem which can be readily identified and measured consistently. While the specific structural attributes that characterize old-growth may vary widely according to forest type, climate, site conditions and disturbance regime, old-growth is typically distinguished by the following:

1. Large size trees of specific species,
2. Wide variation in age classes and stocking levels,
3. Accumulations of large-size dead standing and fallen trees,
4. Decadence in the form of broken or deformed tops and boles,
5. Multiple canopy layers,
6. Canopy interspaces and understory patchiness.

National direction requires old-growth values be considered in designing the dispersion of old-growth (Appendix 2). The values may range from a network of old-growth stands for wildlife habitat to designated areas for recreational opportunities. In general, areas to be managed for old-growth values are to be distributed over individual National Forests with attention given to minimizing the fragmentation of old-growth into small isolated areas.

As a National standard, five structural attributes were identified for Regional consideration as they develop minimum criteria for old-growth determination; however, not all attributes need to be determined. The attributes were live trees in main canopy, variation in tree diameters, dead trees, tree decadence, and number of tree canopies criteria. The Regions could also add optional attributes if they were considered important in determining old-growth.

The Regional old-growth definitions are to be placed in the Forest Service Manual System (biological diversity and/or inventory sections) when completed.

B. Regional Level

The Southwestern Region Old-growth Core Team (Appendix 3) was organized in 1989 ***to develop and recommend old-growth definitions for the forest cover types that occur in this Region.***

Old-growth definitions were developed for the pinyon-juniper, ponderosa pine, aspen, mixed-species, and spruce-fir forest cover types. The aspen forest cover type was added because it has important values in the southwest, even though it provides the normal early or mid-successional pathway for the conifer forests. The riparian community type (cottonwood-willow) was considered but insufficient information was available to develop definitions.

An old-growth data base was developed for the Region to help define some of the inventory structural attributes for old-growth. The procedure used to develop the old-growth data base is described in Appendix 4.

The old-growth definitions were coordinated with the Intermountain and Rocky Mountain Regions for consistence between the various forest ecosystems. There appeared to be little or no relationship between the forest ecosystems in the Southwestern Region and the Intermountain Region. There are similar ecosystem relationships with some of the forest cover types between the Southwestern and southern portion of the Rocky Mountain Regions. The Rocky Mountain Region aspen forest cover type old-growth definition was used for the Southwestern Region.

In addition to developing old-growth definitions, an old-growth implementation procedure was developed and is recommended to be used for old-growth allocation.

The Regional Old-growth Core Team provided the following recommendations applicable for Regional standards and appropriate for use in all Forest Land Management Plans in the Southwestern Region.

The following brief statements are a summary of the Core Team's recommendations:

1. Old-growth Definitions

Old-growth definition structural attributes were developed for the five primary forest cover types in the Southwest.

The attributes shown in table 1 for each of the forest cover types are to be used to inventory and identify ***candidate*** stands for old-growth forest classification. The structural attributes will help identify stands that meet the ***minimum threshold*** characteristics to be considered as old-growth forest, excluding any consideration of stand size or location.

Table 1. The Minimum Criteria for the Structural Attributes Used to Determine Old-growth.

FOREST COVER TYPE, NAME	Pinyon-Juniper		Interior Ponderosa Pine		Aspen	Mixed-Species Group		Engelmann Spruce-Subalpine Fir	
FOREST COVER TYPE, SAF CODE	239		237		217	210,211,216,219		206, 209	
SITE CAPABILITY POTENTIAL BREAK BETWEEN LOW AND HIGH SITE			55 Minor			50 Douglas-Fir Edminster & Jump		50 Engelmann Spruce Alexander	
SITE	LOW	HIGH	LOW	HIGH	ALL	LOW	HIGH	LOW	HIGH
1. LIVE TREES IN MAIN CANOPY									
TREES/ACRE	12	30	20	20	20	12	16	20	30
DBH/DRC	9"	12"	14"	18"	14"	18"	20"	10"	14"
AGE (YEARS)	150	200	180	180	100	150	150	140*/170**	140*/170**
2. VARIATION IN TREE DIAMETERS (YES OR NO)	ND	ND	ND	ND	No	ND	ND	ND	ND
3. DEAD TREES									
STANDING									
TREES/ACRE	0.5*	1	1	1	ND	2.5	2.5	3	4
SIZE, DBH/DRC	9"	10"	14"	14"	10"	14"	16"	12"	16"
HEIGHT (FEET)	8'	10'	15'	25'	ND	20'	25'	20'	30'
DOWN									
PIECES/ACRE	2	2**	2	2	ND	4	4	5	5
SIZE (DIAMETER)	9"	10"	12"	12"	ND	12"	12"	12"	12"
LENGTH (FEET)	8'	10'	15'	15'	ND	16'	16'	16'	16'
4. TREE DECADENCE									
TREES/ACRE	ND	ND	ND	ND	ND	ND	ND	ND	ND
5. NUMBER OF TREE CANOPIES	SS/MS	SS/MS	SS/MS	SS/MS	SS	SS/MS	SS/MS	SS/MS	SS/MS
6. TOTAL BA, SQUARE FEET/ACRE	6	24	70	90	ND	80	100	120	140
7. TOTAL CANOPY COVER, PERCENT	20	35	40	50	50	50	60	60	70

PINYON-PINE * Dead limbs help make up dead material deficit. ** Unless removed for firewood or fire burning activities.
SPRUCE-FIR * In mixed corkbark fir and Engelmann spruce stands where Engelmann spruce is less than 50 percent composition in the stand.
** In mixed corkbark fir and Engelmann spruce stands where Engelmann spruce is 50 or more percent composition in the stand.
ND is not determined; SS is single-storied; MS is multi-storied

Table 1 includes the five Nationally required standard structural attributes and two additional attributes considered important by the Core Team. The two additional attributes are total basal area and total canopy cover.

National Forests may, as in the case of the Madrean Oak Woodland of southeastern Arizona, develop definitions for more specific plant communities. Minor modifications in the numerical values of the various attributes are permitted to fit unique local conditions provided such modifications are verifiable and documented. Any modifications of the old-growth definitions is to be documented and reported to the Regional Forester for coordination with other National Forests.

2. Old-growth Allocation Procedure

An interdisciplinary approach using the Integrated Resource Management process is to be used to assign values to the inventoried candidate old-growth stands and to allocate old-growth forests.

3. Old-growth Score Card System

The Core Team did not develop a score card system to rate old-growth, but has recommended that the Rocky Mountain Forest and Range Experiment Station develop a standard method to evaluate the ecological value of old-growth beyond minimum threshold.

As more is learned about the successional pathways for old forests, the old-growth definitions will be modified accordingly.

II. Old-growth Definitions and Descriptions

A. Pinyon-juniper Forest Cover Type

1. Narrative

The pinyon-juniper (239) woodland forest cover type occupies approximately 6.6 million acres or about 32 percent of National Forest land in the Southwestern Region.

The pinyon and juniper species that are in the southwest are Rocky Mountain pinyon, Arizona Pinyon (single-leaf pinyon pine), border pinyon, alligator juniper, redberry juniper, Rocky Mountain juniper, one-seed juniper, Utah juniper, and Pinchot juniper.

Pinyon-juniper woodlands commonly adjoin and integrate to such vegetation as chaparral (shrub dominated communities), grasslands, shrubsteppes (codominat mistures of grasses and shrubs), evergreen oak woodlands (or encinal), and ponderosa pine or other forest types. There are about 70 pinyon-juniper associations that can be described in the southwest (Moir and Carleton 1987).

The specific species or species mix found at any particular site is largely due to climatic, geographic, and elevation differences. Pinyon and juniper trees are found on a wide range of soil conditions.

2. Description

Old-growth pinyon-juniper will be late successional in development with large, old trees older than 150 years, on low sites, and 200 years, on high sites. There may be few standing and down dead trees, but dead branches/limbs and even parts of the stems of older pinyon, and junipers, trees may help make up the dead material deficit. The pinyon-juniper could have either a single-storied or multi-storied structure. Pinyon-juniper stands usually develop under all-aged conditions (early and mid successional stages) until the site becomes fully occupied with older trees (late successional stage).

As indicated by the large number of associations, old-growth pinyon-juniper is variable in composition. The typical woodland pinyon-juniper old-growth would be fairly open with the presence of an understory of grass, forbs, and often shrubs. Since existing pinyon-juniper stands are developing with reduced herbaceous understory competition and without low-intensity ground fires, as occurred prior to the late 1800s, they typically have a larger number of stems and a more dense canopy cover. The less shade tolerant herbaceous understory vegetation is reduced significantly when an overstory reaches around 30 percent.

3. Structural Attributes

The attributes in table 1 are the minimum criteria for threshold old-growth in the pinyon-juniper forest cover type.

4. Old-growth Data Base

a. Mean Live and Dead Standing Trees and Basal Area Per Acre

The mean live and dead standing trees and basal area per acre structural attributes were compared against the old-growth data base to determine how often the minimum criteria were meet or exceeded (Popp and Jackson 1991):

Total number of plots: Low site = 23 High site = 23

Attribute	Number of Plots That Concur	Percent Concur
Mean live trees per acre (table 2; Figure 1)		
Low site	23	100
High site	1	91
Mean dead standing trees per acre (table 3; Figure 6)		
Low site	5 (8"+)	22
High site	5 (8"+)	22
Mean square foot basal area per acre (table 4; Figure 11)		
Low site	23 (5 sq ft+)	100
High site	23 (24 sq ft+)	100

A high site capability potential for pinyon-juniper would indicate there are no abiotic regeneration inhibiting factors and growth is above average.

b. Age Longevity

Swetnam and Brown recently reported that the mean age for pinyon pine was 278 years, as represented from 43 sites and 719 old trees in Arizona and New Mexico. The oldest living pinyon tree, at the time of sampling, was 666 years as shown in table 6 (Swetnam and Brown 1992).

5. Plant Associations (Habitat Types)

Table 7 lists the habitat types that occurred in the pinyon-juniper forest cover type.

B. Ponderosa Pine Forest Cover Type

1. Narrative

The ponderosa pine (237) forest cover type in the Southwestern Region covers approximately 3.9 million acres outside of the wilderness areas and an undermined amount within the reserved areas.

The dominant tree species in the ponderosa pine forest cover type is ponderosa pine. Minor tree species of pinyon pine and juniper occur with ponderosa pine at lower elevations adjacent to the pinyon-juniper forest cover type; although, Rocky mountain and alligator juniper can occur any place within the ponderosa pine type. At higher elevations near the mixed-species group, Southwestern white pine and Gambel oak can be found in abundance, and frequently small amounts of Douglas-fir, white fir, and aspen are present.

Ponderosa pine has been referred to as blackjack and yellow pine in the past. The term blackjack indicated a younger ponderosa pine with dark gray to black bark color. The blackjack's bark is deeply furrowed with narrow ridges between the fissures. In contrast, the term yellow pine was used to indicate an older tree. The older yellow pine's bark is reddish brown to yellow, carrying the color well into the top of the tree; the plates are usually very wide, long and smooth. The bark color transition begins sometime between 120 to 150 years of age, depending upon the geographic location. The older trees also have large branches in the upper portion of the tree, that tends to be perpendicular to the stem and the tree top is flatter than younger more vigorous trees.

Fire was key in shaping Southwestern ponderosa pine forests prior to pre-European settlement. Low-intensity ground fires typically burned through ponderosa pine forests at 3- to 15-year intervals, keeping forests open in appearance, removing competing understory vegetation and down material. Frequent burning resulted in irregularly-shaped large patches with even-aged groups of trees varying in size, age, and density over the landscape.

Fire suppression, timber harvesting, livestock grazing, mining, and recreational uses have altered the pre-settlement conditions. Now the ponderosa pine forests are generally more dense, with many small trees, have fewer large trees, have a greater accumulation of down material, and have sparse herbaceous understory.

2. Description

Old-growth ponderosa pine will be late successional in development with large trees older than 180 years of age; mature tree characteristics will be as described for yellow pine. The size and number of large trees will represent the productivity of the site, with fewer and smaller trees on the lower sites. Minimums are at least one large dead standing tree and two large-sized dead down trees per acre. More snags and down logs will not distract from the late successional old-growth characteristics. The structure may be either single-storied or multi-storied. Density will also vary with site productivity; with less basal area and canopy cover on the less productive land.

3. Structural Attributes

The attributes in table 1 are the minimum criteria for threshold old-growth in the ponderosa pine forest cover type.

4. Old-growth Data Base

a. Mean Live and Dead Standing Trees and Basal Area Per Acre

The mean live and dead standing trees and basal area per acre structural attributes were compared against the old-growth data base to determine how often the minimum criteria were meet or exceeded (Popp and Jackson 1991):

Total number of plots: Low site = 219 High site = 384

Attribute	Number of Plots That Concur	Percent Concur
Mean live trees per acre (table 2; Figure 2)		
Low site	171	78
High site	210	55
Mean dead standing trees per acre (table 3; Figure 7)		
Low site	31 (12"+)	14
High site	51 (12"+)	13
Mean square foot basal area per acre (table 4; Figure 12)		
Low site	155	71
High site	304	79

A site index of 55 was established as a breaking point between the low and high sites for the structural attributes (Minor 1964).

b. Age Longevity (Referenced tables 5 and 6)

Pearson states the oldest ponderosa pine recorded in the Southwest was 650 years. Trees over 400 years are found occasionally, but mature trees in general are not much over 300 years old and most are less than 200 years old (Pearson 1950).

White found that trees in the Gus Pearson Natural Area ranged in age up to 405 years, but the majority of the trees were less than 200 years; peak ages were between 145 and 165 years (White 1985). Covington's and Moore's data appears to show a rapid decline in the number of large ponderosa pine trees at about 200 years of age when a dense understory exists (Covington and Moore 1991). Daniel states that ponderosa pine remains physiologically young up to 200 years of age in its response to thinning (Daniel 1980).

Swetnam and Brown recently reported that the mean age for ponderosa pine was 279 years. There data set represented 62 sites and 915 old trees in Arizona and New Mexico. The oldest known living ponderosa pine tree, at the time of survey, was 742 years (Swetnam and Brown 1992).

5. Plant Associations (Habitat Types)

Table 8 lists the habitat types that occurred in the ponderosa pine forest cover type.

C. Aspen Forest Cover Type

1. Narrative

The aspen forest cover type (217) seldom, if ever, occurs as a pure stand of quaking aspen or as the climax species in the southwest; it always appears in association with one or more other tree species as the seral species. Species that are associated with it are ponderosa pine, Douglas-fir, Engelmann spruce, limber pine, subalpine fir, white fir, and Southwestern white pine.

Aspen is one of the first species that regenerates after a wildfire or similar disturbance, **if the clone is present**. Aspen will quickly sucker from an existing live root system following a disturbance that kills the upper portion of the aspen tree (aspen does not normally regenerate from seed in the southwest). Rapid growth occurs after suckering and during the early stand development years. With increasing stand age, conifer seedlings, from surrounding conifer seed trees, eventually become established and grow in the shade of the aspen; aspen acting like a nurse crop to the conifers. Since aspen is relatively short lived and conifers longer lived, the conifers eventually out grow aspen, replacing the aspen, first as a mixed type and finally as a conifer type.

2. Description

Aspen old-growth would be characterized as having a single canopy overstory layer of old aspen trees at least 100 years of age. There would be an understory of conifers; however, there could be instances where the understory conifers would be removed by cutting to keep an open appearance for a specific value. There would probably be few dead standing and down trees until the old aspen trees begin to degenerate from pathogenic causes, then down dead material would begin to accumulate. As the overstory aspen trees continue to die, the understory conifers would begin to dominate the stand as an early or mid successional stage, depending upon their size and development, and the old-growth stand will no longer exist. Aspen old-growth, at the best, is short term in duration.

3. Structural Attributes

The attributes in table 1 are the minimum criteria for threshold old-growth in the aspen forest cover type.

4. Old-growth Data Base

a. Mean Live and Dead Standing Trees and Basal Area Per Acre

No comparisons were made against the old-growth data base to determine how often the minimum criteria were meet or exceeded; however, tables 2, 3, and 4 and figures 3, 8, and 13 summarize data for aspen.

b. Age Longevity

Aspen is a small-to medium-sized, fast-growing and short-lived tree. Aspen is susceptible to a large number of diseases and is host to a wide variety of insects. The insects, many of them defoliators, tend to reduce the tree's vigor, but are not the major cause to tree death. Diseases are the primary cause for the short life of aspen. A few vigorous trees attain a maximum age of about 200 years, oldest recorded is 226. The pathological age of aspen in the West ranges from 80 to 120 years, table 5, (Perala 1990, Hunter 1989).

5. Plant Associations (Habitat Types)

No habitat type list was developed for aspen. Aspen does not occur as a habitat type in the southwest. Aspen can occur as a forest cover type in any plant association where aspen is present; however, aspen would be considered a seral species (an early successional species).

D. Mixed-species Group Forest Cover Types

1. Narrative

There are several forest cover types included in the mixed-species group. The mixed-species group includes the Douglas-fir (210), white fir (211), blue spruce (216), and limber pine (219) forest cover types. Most often the mixed-species stands have a rich diversity of vegetation, including three or four different tree species, sometimes more (Krauch 1956).

The major tree species found in this group are Douglas-fir and white fir. Often included in minor amounts are tree species such as subalpine fir, corkbark fir, Engelmann spruce, blue spruce, Southwestern white pine, ponderosa pine, aspen, and Gambel oak.

The mixed-species group is a productive forest component. This group occurs on the landscape at a middle elevation between the lower elevation ponderosa pine forest cover type and the higher elevation Engelmann spruce-subalpine fir forest cover type. The mean annual precipitation in the Douglas-fir zone averages a little more than 26 inches and the growing season is of adequate length for good growth response (Krauch 1956).

The various tree species all have different shade tolerance levels, regeneration requirements, and growth characteristics. Therefore, for trees, the tolerance of most practical importance is their ability to establish and grow satisfactorily in the shade of, and in competition with, other larger trees. Shade tolerant tree species express their presence and increase in number as a mixed-species stand grows older (mid and late succession stages) and/or becomes more dense. There is a gradual change in species composition to the more shade tolerant species without natural or man-caused disturbance.

The tolerance of the associated species has been given as subalpine fir ≥ Engelmann spruce ≥ corkbark fir > white fir > Douglas-fir ≥ blue spruce > Southwestern white pine ≥ limber pine > ponderosa pine > aspen ≥ Gambel oak (Daniel 1980). Limber pine and Gambel oak were added to Daniel's reference as observed in the Southwest.

Before European settlement of the southwest, low-intensity, ground fires in mixed-species forests occurred at lesser intervals than in ponderosa pine. Ground fires burned more frequent on dry, low elevation sites and less frequent on moist, high elevation sites. The fires keep the forest open, allowing less shade tolerant tree species such as ponderosa pine, aspen, and Gambel oak to establish and grow.

Since fire suppression management was started in the early 1900s, mixed-species forest structure and composition has changed. The structural change has been to increased crown cover and basal area densities, more trees, especially smaller trees, forming a multi-storied condition. The compositional change has been to the more shade tolerant species such as white fir and Douglas-fir. Furthermore, the lack of fire and change in conditions has increased the susceptibility of the forest to insect and disease agents.

2. Description

Old-growth mixed species group forest cover types will be late successional in development with large trees older than 150 years. The size and number of large trees will represent the productivity of the site, with fewer and smaller trees on the lower sites. The forest should have a diverse composition of tree species; aspen may not be present in this stage. At least 3.5 large dead standing trees and 4 large dead down pieces per acre of any species will be present. The forest structure can be either single-storied or multi-storied. Basal area and canopy cover densities will vary depending upon the productive capability of the land.

3. Structural Attributes

The attributes in table 1 are the minimum criteria for threshold old-growth in the mixed-species (forest cover type).

4. Old-growth Data Base

a. Mean Live and Dead Standing Trees and Basal Area Per Acre

The mean live and dead standing trees and basal area per acre structural attributes were compared against the old-growth data base to determine now often the minimum criteria were meet or exceeded (Popp and Jackson 1991):

Total number of plots: Low site = 72 High site = 289

Attribute	Number of Plots That Concur	Percent Concur
Mean live trees per acre (table 2; Figure 4)		
Low site	47	65
High site	168	58
Mean dead standing trees per acre (table 3; Figure 9)		
Low site	20 (12"+)	28
High site	55	19
Mean square foot basal area per acre (table 4; Figure 14)		
Low site	67	93
High site	264	91

A site index of 50 for Douglas-fir was established as a breaking point between the low and high sites for the structural attributes (Edminster and Jump 1976).

b. Age Longevity (Reference tables 5 and 6)

Douglas-fir

Coastal Douglas-fir is considered very long lived. Ages in excess of 500 years are not uncommon and some have exceeded 1,000 years; however, interior Douglas-fir rarely lives more than 400 years (Hermann and Lavendar 1990). Hunter lists the maximum longevity age for Douglas-fir to be 1,000 years and the pathological longevity age of 150 years (Hunter 1989). Lynch reported sampling 13 live Douglas-fir trees on the Carson National Forest that were greater than 600 years of age; five of the trees were 700 - 779 years old (Lynch 1990).

Swetnam and Brown recently reported that the mean age for Douglas-fir to be 278 years, as represented on 38 sites, 526 old trees in Arizona and New Mexico. The oldest living Douglas-fir tree, at the time of sampling, was 930 years (Swetnam and Brown 1992).

White Fir

Coastal white fir does not often exceed 350 years, but 500-year-old trees have been reported; however, the maximum age in the interior may be close to 300 years (Markstrom and McElderry 1984). Hunter lists the maximum longevity age for white fir to be 360 years and the pathological longevity age of 150 years (Hunter 1989). The oldest known living white fir tree in Arizona and New Mexico, at the time of sampling, was 333 years (Swetnam and Brown 1992).

Subalpine Fir

The subalpine fir/corkbark fir trees often live for more than 250 years (Markstrom and McElderry 1984). Hunter lists the maximum longevity age for subalpine fir to be 250 years and the pathological longevity age of 130 years (Hunter 1989). Alexander recognized that the species suffers severely from heart rot, many trees either die or are complete culls at an early age (Alexander 1987).

Engelmann Spruce

Engelmann spruce matures at about 300 years, often dominant spruce are 250 to 450 years old, and trees 500 to 600 years are not uncommon (Alexander and Sheppard 1990).

Blue Spruce

Blue spruce is apparently a long-lived tree, often reaching up to 600 years or more in age (Fechner 1990).

Southwestern White Pine

Southwestern white pine has very little information concerning longevity; however, it is observed that Southwestern white pine could have the same longevity attributes as Eastern white pine. The maximum longevity is 450 years and the pathological longevity is 160 - 170 years for Eastern white pine (Hunter 1989). The age of decline for Western white pine is 300 - 400 years and the oldest age 500 years (Graham 1990). The oldest known living Southwestern white pine tree in Arizona and New Mexico, at the time of sampling, was 538 years (Swetnam and Brown 1992).

Limber Pine

Preston indicates that limber pine reaches maturity in 200 - 300 years (Preston 1961). One tree in southern California was found to be well over 1,000 years; another in central Idaho was 1,650 years old (Steele 1990). Lynch reported finding limber pine trees on the Carson National Forest that were hollow; the outer stem measured 1,500 - 1,700 years old. Lynch is confident that trees measured 2,000 years old are located in this area (Lynch 1990). The oldest known living limber pine found in Arizona and New Mexico reported by Swetnam and Brown, at the time of sampling, was 1,670 years (Swetnam and Brown 1992).

Aspen

Aspen is a short-lived tree attaining a maximum longevity age of about 200 years (oldest recorded is 226 years) in the western United States. The pathological longevity age will range between 80 - 120 years (Perala 1990). Hunter indicates the maximum longevity age for aspen to be 200 years and the pathological age of 40 - 120 years (Hunter 1989). The lower age of 40 years is for the East since both growth and decay are generally slower in the West than in the East.

Gambel Oak

Gambel oak is considered a short-lived tree. A study in the Navajo National Monument, Arizona, indicated that oak stems rarely live longer than 80 years, 103 was the oldest stem found. In addition, most 90 percent or more, of the stems encountered in long-established clones were less than ten years old (Brotherson et al. 1983). The oldest known living Gambel oak tree in Arizona and New Mexico, at the time of sampling, was 401 years (Swetnam and Brown 1992).

5. Plant Associations (Habitat Types)

Table 9 lists the habitat types that occurred in the mixed-conifer forest cover type.

E. Engelmann Spruce-Subalpine Fir Forest Cover Type

1. Narrative

The dominant tree species in the spruce-fir (206) forest cover type are Engelmann spruce and subalpine fir. Minor tree species of Douglas-fir, blue spruce, white fir, limber pine, aspen and occasionally ponderosa pine associate at the lower elevations, and corkbark fir, and bristlecone pine at the higher elevations. The bristlecone pine (209) forest cover type is included with the spruce-fir description.

Engelmann spruce and subalpine fir occur as codominants or in nearly pure stands of one or the other species. Engelmann spruce generally extends above subalpine fir and corkbark fir, forming nearly pure stands at timberline.

Spruce-fir forests have lower fire frequencies than the ponderosa pine and mixed-species. The frequencies are from 63 to 400 years and are usually stand replacement events.

2. Description

Old-growth spruce-fir will be late successional in development with large trees older than 140 years where Engelmann spruce is less than 50 percent composition and 170 year old where Engelmann spruce is 50 or more percent composition of the stand. The size and number of large trees will vary with site productivity, with fewer and smaller trees on the lower sites. There is usually an over-abundance of standing dead and down trees. The structure will more than likely be two- or more-storied with natural regeneration appearing in gaps or small openings causes by the death of one or more of the large trees. Density will usually be high; but will be slightly less on the less productive sites.

Bristlecone pine is much less tolerant to shade than Engelmann spruce and subalpine fir and therefore would almost always be the pioneer species for spruce-fir stands. However, occasionally, old-growth bristlecone pine may occur in small-sized patches on very harsh, exposed sites. Where it does occur, it would have small tree-sized Characteristics.

3. Structural Attributes

The attributes in table 1 are the minimum criteria for threshold old-growth in the spruce-fir forest cover type.

4. Old-growth Data Base

a. Mean Live and Dead Standing Trees and Basal Area Per Acre

The mean live and dead standing trees and basal area per acre structural attributes were compared against the old-growth data base to determine how often the minimum criteria were meet or exceeded (Popp and Jackson 1991):

Total number of plots: Low site = 99 High site = 143

Attribute	Number of Plots That Concur	Percent Concur
Mean live trees per acre (table 2; Figure 5)		
Low site	99	100
High site	117	82
Mean dead standing trees per acre (table 3; Figure 10)		
Low site	67	68
High site	54	38
Mean square foot basal area per acre (table 4; Figure 15)		
Low site	95	96
High site	134	94

A site index of 50 for Engelmann spruce was established as a breeding point between the low and high sites for the structural attributes (Alexander 1967).

b. Age Longevity (Reference tables 5 and 6)

The pathological and maximum longevity ages for all species in the spruce-fir have been discussed in the mixed-species forest cover type except for bristlecone pine. The bristlecone pine grows very slow, reaches maturity in 200 - 250 years, obtaining ages of over 2,000 years, possibly the oldest living organism (Preston 1961).

Swetnam and Brown recently reported that the oldest known living Bristlecone pine and Engelmann spruce trees in Arizona and New Mexico, at the time of sampling, was 1,438 and 295 years respectively (Swetnam and Brown 1992).

5. Plant Associations (Habitat Types)

Table 10 lists the habitat types that occurred in the spruce-fir forest cover type.

III. OLD-GROWTH ALLOCATION PROCEDURE

National Forests should use the Integrated Resource Management (IRM) process, either at the project or Forest level, to classify, assign values, and allocate the candidate stands for old-growth. The management direction in the Forest Land Management Plan will be applied to allocate old-growth stands, with consideration given to the stand or patch size, location, and other resource values specified in the Forest Plan.

A. Integrated Resource Management Guidelines and Comments

During the IRM process the following guidelines and comments are to be considered for all forest cover types when applying the structural attribute criteria to identify sites that are potential candidates for functional old growth:

1. For purposes of classification and mapping old-growth is based on readily identifiable structural (physical) characteristics. As such, inventory delineations may not represent the classic stability of late successional communities, or even sustainable forests. A combination of fire control and livestock grazing has caused many stands to develop denser overstories, while losing grass cover and associated understory vegetation. Structurally, these stands are old-growth, but cannot be considered typical late successional or climax communities in that they lack some ecological structural elements such as the understory composition expected for these ecosystems.

2. Gaps in the canopy and patchiness within an old-growth stand is a desired characteristic and is as important as vertical heterogeneity (all age classes) .

3. The structure, stand adjacency and function of an old-growth ecosystem will be influenced by its size and position on the landscape. Small expanses or contiguous patches of old growth may serve as important corridors for migration of both plants and animals.

   A minimum size of 100 acres is frequently cited as the lower spatial limit for a contiguous old-growth community. While this is perhaps a good rule of thumb, configuration is as important as spatial extent. Edge effect and forest interior are two of the primary factors to be considered in assessing forest fragmentation. Delineations of areas other than migration corridors should always attempt to select configurations that will promote forest interior and minimize edge effect caused by fragmentation.

   Old-growth size may be as small as a patch, if it functions in such a way to accomplish the value or purpose for which it was established.

4. Old-growth ecology deals with complex forest processes. Stands with old-growth structural attributes may still require silvicultural treatment to

achieve and maintain the desired ecosystem function or value assigned to the forest. Prescribed fire as well as other silvicultural treatments can be used to manage recruitment old growth. Treatments that will bring about the desired functional condition as quickly as possible should be considered.

5. Often, on a particular site, the assemblage of species is a reflection of the Pleistocene events. Old-growth characteristics can rarely be preserved forever on a site (the stand level). Components of an old-growth community may survive for decades or the life time of those persons now living, but we can only manage to perpetuate sufficient old-growth component at a landscape level.

6. Current old-growth forest conditions are now much different than European pre-settlement forests. The structural attributes are stated to allow National Forests the opportunity to create (as much as possible) or to duplicate pre-settlement conditions by using silvicultural treatments, including prescribed fire prescriptions.

7. By any definition old-growth can have evidence of past tree cutting including stumps, slash, down logs, roads, fences and other improvements. Identification of areas without man's evidence should also be identified.

8. Down logs must be sections of log, not a chunk or piece less than the minimum size. The down log size and length is specified to be functional for fungi and certain small animals. However, there may be exceptions in the down log structural attribute requirement; down material may be missing, especially in the pinyon-juniper and ponderosa pine forest cover types because of past fuel treatment requirements or firewood gathering practices. If missing, down logs can be created to have an ecologically functioning old-growth stand.

9. Communities of old-growth may consist of an overstory of trees with a single, or no understory, or they may consist of the tree overstory with a well-developed understory with layers of young trees, and shrubs and herbaceous vegetation.

10. Old-growth communities must be distributed proportionately among the various forest cover types, site capabilities, and plant associations (habitat types) that are found on the National Forest.

11. The structural attributes are intended to permit inventory of the individual forest cover types. The structural attributes are defined in the glossary.

12. There is a scientific value for old-growth as a legacy for future generations.

IV. Old-growth Score Card System

The Rocky Mountain Forest and Range Experiment Station should develop a standard score card system to classify old-growth as either recruitment, threshold, preferred (quality). or degenerate (marginal) old-growth. The score card should consider the ecological importan-- and successional pathways of old-growth.

V. Research Needs for Ecological Old-growth

The old-growth definitions in this paper were developed by reviewing and using the limited research data available for the Southwestern Region. Additional old-growth research is needed to refine and adjust, where necessary, the old-growth definitions in the future. The following basic, as well as ecosystem function questions need to be studies:

A. What Do We Know Now?

Literature review.

B. What is Ecological Old-growth?

Develop baseline.
  Pre-settlement conditions with frequent ground fires.
  Post-settlement conditions without ground fires.
Verify structural attributes by forest cover types/plant associations.
Key structural attributes to measure.

C. What is Important for Old-growth to Function?

Live old trees
Small mammal use
Birds and other animals
Soil productivity
Organic matter
Single/multiple storied
Pathogen response
Factors of sustainability, including periodic fire
Soil fertility processes
Dead trees, standing and down
Gap response
Openings response
Decadence
Microorganisms
Nutrient cycling
Vegetation establishment and Growth
Entomological relationships, especially bark beetles and Western budworm
Carbon budget responses

D. What Are the Changes in Genetic and Biological Diversity?

E. What Silvicultural Treatments Can We Use for Old-growth?

To create/develop.
To maintain.

F. Can Old-growth Quality be Measured?

Develop a Score card approach.

G. Does the Riparian Community have an Old-growth Stage?

LIST OF REFERENCES

Alexander, R. R., "Site indexes for Engelmann spruce," *U.S. Forest Service Research Paper*, RM-32, pp. 7 (1967), Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Alexander, R. R., "Ecology, silviculture, and management of the Engelmann spruce-subalpine fir type in the Central and Southern Rocky Mountains," *USDA Forest Service, General Technical Report*, RM-162, (1987), Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Alexander, R. R. and Sheppard, W. D., "Engelmann spruce In Silvics of North America," *U.S. Department of Agriculture, Forest Service, Agriculture*, Handbook 654, Volume 1, Conifers, (1990), Washington.

Brotherson, J. D., Rushfort, S. R., Evenson, W. E., Johansen, J. R., and Morden, C., "Population dynamics and age relationships of eight tree species in Navajo National Monument, Arizona," *Journal of Range Management*, 36:250 - 256 (1983).

Boyce, J. S., "Forest pathology", Edition 3, (1961), McGraw - Hill Book Co., New York, NY.

Covington, W. W. and Moore, M. M., "Changes in forest conditions and multiresource yields from ponderosa pine forests since European settlement," *Water Resources Operations*, Final Report, pp. 51 (1991), Salt River Project, Phoenix, Arizona.

Daniel, T. W., "The Middle and Southern Rocky Mountain Region," *Regional Silviculture of the United States*, Second Edition (1980), John Wiley and Sons, New York, NY.

Edminster, C. B. and Jump, L. H., "Site index curves for Douglas-fir in New Mexico," *USDA Forest Service, Research Note*, RM-326, pp. 3, (1976), Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Erye, F. H., "Forest cover types of the United States and Canada," *Society of American Foresters*, pp. 148, (1980), Washington, D.C.

Fechner, G. H., "Blue spruce In Silvics of North America," *U.S. Department of Agriculture, Forest Service, Agriculture*, Handbook 654, Volume 1, Conifers, (1990), Washington.

Ford-Robertson, F. C., "Terminology of forest science, technology, practice & products," *Society of American Foresters*, pp. 349, (1971), Washington, D.C.

Graham, R. T., "Western white pine In Silvics of North America," *U.S. Department of Agriculture, Forest Service, Agriculture*, Handbook 654, Volume 1, Conifers, (1990), Washington

Gottfried, G. J., "Five-year growth and development in a virgin Arizona mixed conifer stand," *USDA Forest Service, Research Paper* RM-203, (1978), Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Hawksworth, F. G. and Geils, B. W., "How long do mistletoe-infected ponderosa pines live?," *Western Journal of Applied Forestry*, 5(2):47-48, (1990).

Hermann, R. K. and Lavender, D. P., "Douglas-fir In Silvics of North America," *U.S. Department of Agriculture, Forest Service, Agriculture*, Handbook 654, Volume 1, Conifers, (1990), Washington.

Hunter, M. L., Jr., "What constitutes an old-growth stand?," *Journal of Forestry*, Volume 89(8), (1989).

Jones, J. R., "Silviculture of southwestern mixed conifers and aspen: the status of our knowledge," *USDA Forest Service; Research Paper*, RM-122, pp. 44 (1974), Rocky Mountain Forest and Range Experiment Station, Fort Collins, Co.

Krauch, H., "Management of Douglas-fir timberland in the Southwest," *USDA Forest Service Station Paper*, No. 21, pp. 59 (1956), Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Lynch, A. M., "Oldest Douglas-fir tree in the Southwest," *Memo to Christina Gonzalez, Acting Forest Supervisor, Carson National Forest*, Reply to 4500, March 5, 1990.

Markstrom, D. C. and S. F. McElderry, "White fir, an American wood," *USDA Forest Service* FS-237, (1984).

Minor, C. O., "Site-index curves for young-growth ponderosa pine in Northern Arizona," *Research Note 37, Fort Collins, CO.*, pp. 8, (1964), U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.

Moir, W. H. and J. H. Dieterich, "Old-growth ponderosa pine from succession in pine-bunchgrass forests in Arizona and New Mexico," *Natural Areas Journal*, Volume 8 (1), pp. 17-24, (1988).

Moir, W. H. and J. O. Carleton, "Classification of pinyon-juniper (PJ) sites on national forests in the southwest," *Proceedings - Pinyon-Juniper Conference, General Technical Report*, INT-215, (1987), U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, UT.

Muldavin, E., Ronco, F. Jr. and E. F. Aldon, "Consolidated stand tables and biodiversity data base for southwestern forest habitat types," *General Technical Report, Fort Collins CO.*, RM-190, pp. 51, (1990), U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.

Pearson, G. A., "Management of ponderosa pine in the Southwest," *Agriculture Monograph 6*, pp. 218, (1950), Washington, D.C.

Perala, D. A., "Quaking aspen In Silvics of North America," *U.S. Department of Agriculture, Forest Service, Agriculture* Handbook 654, Volume 1, Conifers, (1990), Washington.

Popp, J. B. and Jackson, P. D., *A preliminary analysis of proposed old-growth definitions in Region 3*, pp. 27, (1991), USDA Forest Service, Southwestern Region, Timber Management Staff Unit, Albuquerque, NM.

Popp, J. B., Jackson, P. D. and Bassett, R. L., "Old-growth concepts from habitat type data in the Southwest," *Old-growth forests in the Southwest and Rocky Mountain Regions, proceedings of a workshop*, General Technical Report RM-213, pp. 100-105, (1992), U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Preston, R. J., Jr., "North American trees," (1961) The Iowa State University Press, Ames Iowa.

Swetnam, T. W. and Brown, P. M., "Oldest known conifers in the Southwestern United States: temporal and spatial arrangement of maximum age," *Proceedings: Old-Growth Forests in the Southwest and Rocky Mountain Regions, Proceedings of a Workshop*, General Technical Report RM-213, pp. 24-38, (1992), Fort Collins, CO., U.S. Department of Agriculture, Rocky Mountain Forest and Range Experiment Station.

Steele, R., "Limber pine In Silvics of North America," *USDA Forest Service, Agriculture* Handbook 654, Volume 1, Conifers, (1990), Washington, D.C.

USDA Forest Service, *New Mexico forest survey field procedures*, (1986-1987), USDA Forest Service, Intermountain Research Station, Ogden, UT.

White, A. S., "Pre-settlement regeneration patterns in a southwestern ponderosa pine stand," *The Ecological Society of America*, Ecology 66(2), pp 589-594, (1985).

LIST OF COMMON AND SCIENTIFIC NAMES OF TREES

Common Species Name	Scientific Name
Alligator juniper	**Juniperus deppeana**
Apache pine	Pinus engelmannii
Arizona cypress	Cupressus arizonica
Arizona pine	Pinus ponderosa var. arizonica
Arizona pinyon pine*	**Pinus fallax**
Arizona sycamore	Platanus wrightii
Arizona white and Gray oak	Quercus arizonica Quercus grisea
Ash	Fraxinus sp.
Aspen	**Populus tremula var. tremuloides**
Bigtooth maple	Acer saccharum var. grandidentatum
Blue spruce	**Picea pungens**
Border pinyon pine	**Pinus discolor**
Boxelder	Acer negundo
Bristlecone pine	**Pinus aristata**
Chihuahua pine	Pinus leiophylla
Corkbark fir	**Abies lasiocarpa var. arizonica**
Cottonwood	Populus sp.
Douglas-fir	**Pseudotsuga menziesii var. glauca**
Emory oak	Quercus emoryi
Engelmann spruce	**Picea engelmannii**
Gambel oak	**Quercus gambelii**
Hackberry	Celtis sp.
Limber pine	**Pinus flexilis**
New Mexico locust	Robinia neo-mexicana
Mexican blue oak	Quercus oblongifolia
One-seed juniper	**Juniperus monosperma**
Pinchot juniper	**Juniperus pinchotii**
Redberry juniper	**Juniperus erythrocarpa**
Rocky Mountain juniper	**Juniperus scopulorum**
Rocky Mountain maple	Acer glabrum
Rocky Mountain pinyon pine**	**Pinus edulis**
Silverleaf oak	Quercus hypoleucoides
Southwestern ponderosa pine	**Pinus ponderosa var. scopulorum**
Southwestern white pine	**Pinus strobiformis**
Subalpine fir	**Abies lasiocarpa var. lasiocarpa**
Tamarisk	Tamarix chinensis
Utah juniper	**Juniperus osteosperma**
Walnut	Juglans sp.
Wavyleaf oak	Quercus undulata
White fir	**Abies concolor**
Willow	Salix sp.

* Singleleaf pinyon pine is now Arizona pinyon pine
** Pinus edulis has been renamed Rocky Mountain pinyon pine
Bold indicates species discussed in this report.

GLOSSARY

Attributes - The elements that are measured to determine the classification of an old-growth stand (table 1). They are as follows:

1. Live trees in the main canopy

    Live trees - Trees with some or many visible living, green leaves or needles that are present some time during a year.

    Main canopy - The largest group of trees or single trees in a (site) stand. The dominant and codominant trees.

    Trees/acre - An average number of live large trees in the main canopy of a stand on a number per acre basis.

    (DBH) Diameter breast height - The outside bark diameter of a live large tree and dead standing tree measured at breast height. Breast height is 4.5 feet above the forest floor on the uphill side of the tree. If the bark has fallen from the dead standing tree, the stem is measured without the bark. Use DBH for timber species.

    (DRC) Diameter root collar - The outside bark diameter of a live large tree and dead standing tree measured slightly (2 inches) above the break between root collar and the normal-taper of the stem. Root collar is the region where root and stem merge. If the bark has fallen from the dead standing tree, the stem is measured without the bark. If the tree is multistemed, the equivalent diameter root collar (EDRC) is calculated and the tree will represent one tree per acre. Use DRC for woodland (other tree species).

    Age (years) - The mean age of the large live trees (dominant and codominant) in the stand. Age is measured by boring a tree at breast height (BH) (timber species) or root collar (RC) (woodland, other tree species). The years that is required for a timber species to grow to breast height will be added to the BH age to determine total tree age. The age at RC is the total tree age for woodland, other tree species.

2. Variation in tree diameters (Not determined)

3. Dead trees

    Dead Tree - A tree that is not alive.

    Standing - Any tree, vertical or near vertical, that is supporting itself or leaning on another tree. A standing dead tree is called a snag.

Trees/acre - An average number of dead standing trees in a stand on a number per acre basis.

Size, DBH/DRC - The same definition as above applies.

Height (feet) - The total span of a dead standing tree measured in feet from ground level along the bole on the uphill side of the tree to the tip of the tree. If the tip of the tree is missing, measure to the broken top.

Down Logs - Dead trees that are lying on the forest floor. They may be in tree length or broken into several sections. Any section that meets the minimum criteria may be counted as a down log.

Pieces/acre - An average number of dead down logs in a stand on a number per acre basis.

Size (diameter) - The measured diameter of a down log recorded in inches at the large end of the down log.

Length (feet) - The measured distance in feet from one broken end of a down log to the other end.

4. Tree decadence (Not determined)

5. Number of tree canopies (Can be either single- or multi-storied)

Storey - A roughly horizontal stratum, i.e. layer, of vegetation formed by a plant community, in forests essentially by their canopy layers. Note: A forest may have one or more such storeys, and hence be single-storied, two-storied, or multi-storied. (Ford-Robertson 1971)

6. Total BA, square feet/acre

Total BA, square feet/acre - The cross section area taken at DBH or DRC for all live trees in a stand. Basal area is expressed as the number of square feet per acre.

7. Total canopy cover, percent

Total Canopy Cover, percent - The percentage of the ground covered by the vertical projection of the outermost perimeter of the natural spread of the foliage for all live trees. Small openings in the crown are included. Total canopy cover can never exceed 100 percent. Canopy cover can be measured either from current aerial photographs, landsat, or in the field with a densiometer.

Classification of old-growth - See old-growth classification.

Forest cover type - A descriptive classification of forest land based on present occupancy of an area by tree species (Eyre 1980). Forest cover types are named after predominant tree species. Predominance is determined by basal area and the name is confined to one (ponderosa pine) or two species (pinyon-juniper and Engelmann spruce-subalpine fir). The mixed-species/mixed conifer forest cover type per se is not a forest cover type but includes several cover types.

Old-growth classification

Recruitment - A young forest (stand) that is identified to be managed as old-growth in the future. Recruitment old-growth stands do not meet the minimum attribute requirements but will be managed to meet old-growth requirements or to replace deteriorated or marginal old-growth. Recruitment old-growth stands can be considered as potential old-growth.

Threshold - This classification defines the beginning of old-growth in the late successional stage of development. The stand inventory meets or exceeds the minimum attributes for ecological old-growth. An example of threshold old-growth is stage 8 stands of ponderosa pine stands as described by Moir and Dieterich (1988).

Preferred or quality - This classification defines forests (stands) that meet or exceed the minimum attribute old-growth requirements and often is regarded as the climax pre-European settlement forest with an open understory and large yellow pines. Moir and Dieterich (1988) describe stage 10 stands of ponderosa pine as the preferred old-growth.

Degenerate or marginal - This classification defines forests (stands) that meet or exceed the minimum attribute old-growth requirements. They occur in some research natural areas, wildernesses, and parks as well as many areas of suitable forest land where frequent, low intensity, natural fire has been excluded. Moir and Dieterich (1988) have described this as stage 9 stands of ponderosa pine with maturing yellow pine trees and dense thickets developed in the absence of fire. There is considerable accumulation of forest fuels, large dead standing and down trees, and the herbaceour cover is sparce of absent. The Gus Pierson Natural Area on the Fort Valley Experimental Forest is an example of a degenerate old-growth forest.

Site Capability Potential:

Pinyon-juniper forest cover type: It is the potential for the site to regenerate or sustain itself (USDA Forest Service 1986-1987).

Ponderosa Pine, Mixed Species/Mixed Conifer, and Engelmann Spruce-Subalpine Fir forest cover types: Tree growth is related to site capability. Site capability is determined by measuring the age and height of several dominant or codominant good growing trees and comparing the measurements with the appropriate site index table. The procedure is commonly referred to as determining the site index.

APPENDIX 1

GENERIC DEFINITION AND DESCRIPTION OF OLD-GROWTH 10/11/89

Purpose and Scope

The following describes the ecologically important structural features of old-growth ecosystems. Measurable criteria for these attributes will be established in more specific definitions for forest types, habitat types, plant associations or groupings of them. The intent of the generic definition is to guide design of specific definitions and new inventories that include measurement of specific attributes. Although old-growth ecosystems may be distinguished functionally as well as structurally, this definition is restricted primarily to stand-level structural features which are readily measured in forest inventory.

Definition

Old-growth forests are ecosystems distinguished by old trees and related structural attributes. Old growth encompasses the later stages of stand development that typically differ from earlier stages in a variety of characteristics which may include tree size, accumulations of large dead woody material, number of canopy layers, species composition, and ecosystem function.

Description

The age at which old-growth develops and the specific structural attributes that characterize old growth will vary widely according to forest type, climate, site conditions and disturbance regime. For example, old-growth in fire-dependent forest types may not differ from younger forests in the number of canopy layers or accumulation of down woody material. However, old-growth is typically distinguished from younger growth by several of the following attributes:

1. Large trees for species and site.
2. Wide variation in tree sizes and spacing.
3. Accumulations of large-size dead standing and fallen trees that are high relative to earlier stages.
4. Decadence in the form of broken or deformed tops or bole and root decay.
5. Multiple canopy layers
6. Canopy gaps and understory patchiness.

Compositionally, old growth encompasses both older forests dominated by early seral species, such as fire-dependent species, and forests in later successional stages dominated by shade tolerant species. Rates of change in composition and structure are slow relative to younger forests. Different stages or classes of old growth will be recognizable in many forest types.

Sporadic, low to moderate severity disturbances are an integral part of the internal dynamics of many old-growth ecosystems. Canopy openings resulting from the death of overstory trees often give rise to patches of small trees, shrubs, and herbs in the understory.

Old-growth is not necessarily "virgin" or "primeval." Old-growth could develop following human disturbances.

The structure and function of an old-growth ecosystem will be influenced by its stand size and landscape position and context.

APPENDIX 2

POSITION STATEMENT ON NATIONAL FOREST OLD-GROWTH VALUES 10/11/89

The Forest Service recognizes the many significant values associated with old-growth forests, such as biological diversity, wildlife and fisheries habitat, recreation, aesthetics, soil productivity, water quality, and industrial raw material. Old growth on the National Forests will be managed to provide the foregoing values for present and future generations. Decisions on managing existing old-growth forests to provide these values will be made in the development and implementation of forest plans. These plans shall also provide for a succession of young forests into old-growth forests in light of their depletion due to natural events or harvest.

Old-growth forests encompass the late stages of stand development and are distinguished by old trees and related structural attributes. These attributes, such as tree size, canopy layers, snags, and down trees, generally define forests that are in an old-growth condition. The specific attributes vary by forest type. Old-growth definitions are to be developed by forest type or type groups for use in determining the extent and distribution of old-growth forests.

Where goals for providing old-growth values are not compatible with timber harvesting, lands will be classified as unsuitable for timber production. Where these goals can be met by such measures as extending the final harvest age well beyond the normal rotation or by using silvicultural practices that maintain or establish specific old-growth values, lands will be classified as suitable for timber production. In making these determinations, consideration shall be given to the extent and distribution of old growth on National Forest lands that are Congressionally or administratively withdrawn from timber harvest, as well as adjacent ownerships.

Old-growth values shall be considered in designing the dispersion of old growth. This may range from a network of old-growth stands for wildlife habitat to designated areas for public visitation. In general, areas to be managed for old-growth values are to be distributed over individual National Forests with attention given to minimizing the fragmentation of old growth into small isolated areas. Old growth on lands suitable for timber production and not subject to extended rotations is to be scheduled for harvest to establish young stands which more fully utilize potential timber productivity and also meet other resource objectives.

Regions with support from Research shall continue to develop forest type old-growth definitions, conduct old growth inventories, develop and implement silvicultural practices to maintain or establish desired old-growth values, and explore the concept of ecosystem management on a landscape basis. Where appropriate, land management decisions are to maintain future options so the results from the foregoing efforts can be applied in subsequent decisions. Accordingly, field units are to be innovative in planning and carrying out their activities in managing old-growth forests for their many significant values.

APPENDIX 3

SOUTHWESTERN REGION OLD-GROWTH CORE TEAM MEMBERS

Core Team Member	Representing
John Wright	Environmental Working Group Representative
LeRoy Smith	Timber Industry Working Group Representative
W. Wallace Covington	Northern Arizona University, School of Forestry
Craig Allen	National Park Service
Earl F. Aldon	Rocky Mountain Forest and Range Experiment Station
Dwayne Van Hooser	Intermountain Forest and Range Experiment Station
Carolyn Bye	Southwestern Region, Public Affairs Office
Reggie Fletcher	Southwestern Region, Range Management and Ecology
Wayne Robbie	Southwestern Region, Watershed and Air Management
Chuck Jourden	Southwestern Region, Aviation and Fire Management
Rick Wadleigh	Southwestern Region, Wildlife and Fisheries Management
Art Briggs	Southwestern Region, Timber Management
Dick Bassett	Southwestern Region, Timber Management

NOT ALL TEAM MEMBERS AGREED WITH THE FINAL INVENTORY MINIMUM CRITERIA FOR THE STRUCTURAL ATTRIBUTES USED TO DETERMINE OLD-GROWTH.

APPENDIX 4

OLD-GROWTH DATA BASE

Forest and woodland habitat type (plant association) field plot data were used to identify minimum criteria for old-growth structural attributes. Tree data from over 2,000 plant association field plots was summarized into one publication and a data base was developed (Muldavin et al. 1990). Sample trees from the data base was used for the Region's old-growth data base since most of the plots were located in forests, that were in or nearing the late succession stage of forest development.

Popp and Jackson were able to use 1,585 of the tree data plots, along with the field record sheets, to analyze and develop a set of stand tables and graphs to help verify and establish the minimum old-growth criteria (Popp and Jackson 1991, Popp et al. 1992). They then tested live tree, dead standing tree, and basal area per acre criteria for occurrence by forest cover type. The results indicate that the minimum structural attributes in table 1 are realistic and achievable, at least for live trees, dead standing trees, and basal area.

Live Trees

The mean number of live trees per acre is shown in table 2 by 2-inch diameter classes, by no, low, high, and all site indices, and by forest cover type. The number of plots for each forest cover type and site is shown on the right side of the table. The all site plot number represents the total of no, low, and high site plots. Figures 1, 2, 3, 4, and 5 illustrate the same information by bar graph. The bar graph does not illustrate the no site information but, the no site information is included in the all indexes.

Dead Standing Trees

The mean number of dead standing trees per acre is shown in table 3 by 2-inch diameter classes, by no, low, high, and all site indices and by forest cover type. The number of plots for each forest cover type and site is shown on the right side of the table. The all site plot number represents the total of no, low, and high site plots. Figures 6, 7, 8, 9, and 10 illustrate the same information by bar graph. The bar graph does not illustrate the no site information but the no site information is included in the all indexes. All forest cover types had a poor representation of dead standing trees.

Basal Area

The mean square foot basal area per acre is shown in table 4 by 2-inch diameter classes, by no, low, high, and all site indices and by forest cover type. The number of plots for each forest cover type and site is shown on the right side of the table. The all site plot number represents the total of no, low, and high site plots. Figures 11, 12, 13, 14, and 15 illustrate the same information by bar graph. The bar graph does not illustrate the no site information but the no site information is included in the all indexes.

Tree Age

Tree age, dead down trees, and total canopy cover information was not available from the habitat type field plot data. Tree age was determined by looking at the maximum and pathological ages for the various species (table 5). The maximum age or maximum longevity is the age of the oldest tree found to be living. The oldest known trees of several tree species in Arizona and New Mexico are shown in table 6. The table lists the tree age at the time of sampling as well as the location (Swetnam and Brown 1992).

Pathological age is the age at which a tree (or stand of forest trees) begins to show forms of serious decay (Boyce 1961). There are many factors that cause a tree to die at anytime throughout its life. They are wind, lightning, dwarf mistletoe, bark beetles, heart rot, suppression and fire (Hawksworth and Geils 1990, Gottfried 1978, Jones 1974, Krauch 1956, Pierson 1950).

Table 2. Summary Data in 2-inch Diameter Classes for Live Trees Per Acre.

	DIAMETER, DBH/DRC																	
	0-1.9	2-3.9	4-5.9	6-7.9	8-9.9	10-11.9	12-13.9	14-15.9	16-17.9	18-19.9	20-21.9	22-23.9	24-25.9	26-27.9	28-29.9	30-31.9	32+	TOTAL TREES	NUMBER OF PLOTS
PINYON-JUNIPER																			
NO SI	988	77	50	31	20	15	10	6	7	6	2	3	2	2	0	0	1	1220	52
LOW SI	607	81	57	36	32	13	10	6	8	5	3	5	2	3	1	1	1	871	23
HI SI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ALL SI	871	78	52	33	24	14	10	6	7	6	2	4	2	2	0	0	1	1113	75
PONDEROSA PINE																			
NO SI	943	74	53	38	22	18	15	12	9	7	4	6	3	2	1	1	1	1209	137
LOW SI	237	37	24	17	13	11	10	9	7	6	5	3	2	1	1	0	1	384	219
HI SI	316	45	29	20	14	12	10	8	7	6	6	8	3	2	1	0	1	488	384
ALL SI	409	48	32	22	15	13	11	9	7	6	5	6	3	2	1	0	1	591	740
ASPEN																			
NO SI	1027	352	221	109	51	36	17	5	5	4	4	0	1	0	0	0	0	1832	9
LOW SI	554	93	69	90	66	64	31	24	9	3	5	5	1	0	1	0	0	1015	12
HI SI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ALL SI	757	204	134	98	60	52	25	16	7	3	5	3	1	0	1	0	0	1365	21
MIXED-SPECIES																			
NO SI	741	94	60	43	27	24	18	13	9	8	6	5	3	2	1	2	4	1060	126
LOW SI	399	84	56	38	31	21	16	14	8	8	6	4	2	2	1	1	2	693	72
HI SI	510	103	66	40	25	21	18	13	10	8	7	10	2	1	1	1	1	837	289
ALL SI	553	98	63	40	26	22	18	13	9	8	7	8	2	1	1	1	2	873	487
SPRUCE-FIR																			
NO SI	806	114	76	52	51	44	32	22	13	11	7	4	2	2	0	0	0	1236	31
LOW SI	850	136	89	61	45	36	29	19	14	8	8	4	3	2	1	1	1	1307	99
HI SI	854	125	77	56	38	32	31	22	14	10	7	5	2	1	1	1	1	1277	143
ALL SI	847	128	81	57	42	35	30	21	14	9	7	5	2	1	1	1	1	1283	273

Table 3. Summary data in 2-inch diameter classes for dead trees per acre.

	DIAMETER, DBH/DRC																	
	0-1.9	2-3.9	4-5.9	6-7.9	8-9.9	10-11.9	12-13.9	14-15.9	16-17.9	18-19.9	20-21.9	22-23.9	24-25.9	26-27.9	28-29.9	30-31.9	32+	TOTAL TREES	NUMBER OF PLOTS
PINYON-JUNIPER																			
NO SI	29	9	4	2	2	1	0	1	1	0	0	0	0	0	0	0	0	49	52
LOW SI	36	15	7	2	2	0	0	0	0	0	0	0	0	0	0	0	0	62	23
HI SI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ALL SI	31	11	5	2	2	1	0	1	1	0	0	0	0	0	0	0	0	53	75
PONDEROSA PINE																			
NO SI	9	9	4	2	1	1	1	1	0	0	1	1	1	0	0	0	0	31	137
LOW SI	5	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	8	219
HI SI	5	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	10	384
ALL SI	6	3	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	13	740
ASPEN																			
NO SI	101	23	26	4	1	1	1	0	0	0	0	0	0	0	1	0	0	158	9
LOW SI	7	11	12	12	5	5	2	1	0	0	1	0	0	0	0	0	0	56	12
HI SI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ALL SI	47	16	18	9	3	3	2	1	0	0	1	0	0	0	0	0	0	100	21
MIXED-SPECIES																			
NO SI	12	8	7	5	2	2	2	1	1	1	0	1	0	0	0	0	0	42	126
LOW SI	31	20	7	6	3	2	1	1	1	0	0	0	0	0	0	0	0	72	72
HI SI	12	13	8	4	3	2	2	1	1	1	0	1	0	0	0	0	0	48	289
ALL SI	15	13	8	5	3	2	2	1	1	1	0	1	0	0	0	0	0	50	487
SPRUCE-FIR																			
NO SI	17	20	13	12	10	9	3	10	3	3	2	1	0	0	0	0	0	103	31
LOW SI	30	21	16	9	8	7	5	4	2	2	2	0	1	0	0	0	0	107	99
HI SI	22	19	14	10	7	7	5	4	2	2	1	1	1	0	0	0	0	95	143
ALL SI	24	20	15	10	8	7	5	5	2	2	1	1	1	0	0	0	0	100	273

Table 4. Summary Data in 2-inch Diameter Classes for Basal Area Per Acre.

	DIAMETER, DBH/DRC																	
	0- 1.9	2- 3.9	4- 5.9	6- 7.9	8- 9.9	10- 11.9	12- 13.9	14- 15.9	16- 17.9	18- 19.9	20- 21.9	22- 23.9	24- 25.9	26- 27.9	28- 29.9	30- 31.9	32+	TOTAL BA	NUMBER OF PLOTS
PINYON-JUNIPER																			
NO SI	0	1	7	8	9	10	9	8	12	12	5	9	8	7	1	1	10	117	52
LOW SI	0	1	8	10	14	8	9	7	12	10	8	13	8	11	4	5	12	140	23
HI SI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ALL SI	0	1	7	9	11	9	9	8	12	11	6	10	8	8	2	2	11	124	75
PONDEROSA PINE																			
NO SI	0	1	7	10	10	12	13	15	15	14	11	17	9	9	4	5	9	161	137
LOW SI	0	0	3	5	6	7	9	11	11	13	12	8	6	6	2	3	5	107	219
HI SI	0	0	4	5	6	8	9	10	12	13	15	22	10	7	6	2	7	136	384
ALL SI	0	0	4	6	7	8	10	11	12	13	13	17	9	7	4	3	7	132	740
ASPEN																			
NO SI	0	1	30	29	23	24	15	6	8	7	9	0	4	0	0	0	0	156	9
LOW SI	0	0	9	24	29	42	29	30	14	5	13	13	3	0	4	0	0	215	12
HI SI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ALL SI	0	0	18	26	26	34	23	20	11	6	11	7	3	0	2	0	0	190	21
MIXED-SPECIES																			
NO SI	0	0	8	11	12	16	17	16	14	15	14	13	9	8	7	8	32	200	126
LOW SI	0	0	8	10	14	14	15	18	13	16	16	12	7	9	4	5	17	178	72
HI SI	0	0	9	11	11	14	17	16	16	15	17	28	6	5	3	4	11	183	289
ALL SI	0	0	9	11	12	15	17	16	15	15	16	22	7	6	4	5	17	187	487
SPRUCE-FIR																			
NO SI	0	0	10	14	23	29	30	26	21	22	16	12	6	7	2	2	0	220	31
LOW SI	0	0	12	16	20	24	27	24	22	15	18	13	9	6	5	3	9	223	99
HI SI	0	0	11	15	17	21	29	27	22	19	17	15	5	5	3	3	5	214	143
ALL SI	0	0	11	15	19	23	28	26	22	18	17	14	7	6	4	3	6	218	273

Table 5. The Maximum and Pathological Longivity Ages for Several Trees Species in the Southwest.

Species	Oldest Age Years	Age of Decline (Pathological Age) Years	Reference
Aspen	226	80-120	Hunter 1989; Perala 1990
Blue spruce	600	-	Pechner 1990
Bristlecone pine	1,438	200-250	Preston 1961; Swetnam and Brown 1992
Doutlas-fir, Interior	400	150	Hunter 1989; Hermann and Lavendar 1990
Engelmann spruce	500-600	250-450	Alexander and Sheppard 1990
Gambel oak	80-100	10	Brotherson et al. 1983
Limber pine	2,000	200-300	Preston 1961; Lynch 1990; Steele 1990
Ponderosa pine	650	145-200	Pearson 1950; White 1985; Covington and Moore 1991
Eastern white pine	450	160-170	Hunter 1989
Southwestern white pine	Intermediate between eastern and western white pine		
Western white pine	500	300-400	Graham 1990
Subalpine fir/Cork-bark fir	250	130	Markstrom and McElderry 1984; Hunter 1989
White fir, Interior	300-360	150	Markstrom and McElderry 1984; Hunter 1989

Table 6. Oldest Known Living Trees (at time of sampling) of Various Tree Species in Arizona and New Mexico (Swetnam and Brown 1992).

Species	Date of Inner Ring*	Date Sampled	Number of Years	Site Name	Location
ponderosa pine (Pinus ponderosa)	1243	1984	742	Mount Bangs	Mt. Bangs S.E. of Littlefield, AZ
Douglas-fir (Pseudotsuga menziesii)	1062	1991	930	Bandera	El Malpais National Mon. south of Grants, NM
pinon (Pinus edulis)	1295	1960	666	Mariano Lake	N.W. of Gallup, NM
bristlecone pine (Pinus aristata)	547	1984	1,438	San Francisco Peaks	San Fran. Peaks N. of Flagstaff, AZ
limber pine (Pinus Flexilis)	±320	1989	1,670	Elephant Rock	Sangre de Cristo Mtns. E. of Questa, NM
Southwestern white pine (Pinus strobiformis)	±1454	1991	538	Camp Point	Pinaleno Mtns. S.W. of Safford, AZ
white fir (Abies concolor)	1655	1987	333	Alamitos	Sangre de Cristo Mtns. S. of Angostura, NM
Engelmann spruce (Picea engelmannii)	1696	1990	295	Emerald Peak	Pinaleno Mtns. S.W. of Safford, AZ
gambel oak (Quercus gambelli)	±1587	1987	401	Beaver Creek	Beaver Creek S. of Flagstaff, AZ

* ± indicates inner-most ring date is estimated from a ring count only, while other dates are dendrochronologically crossdated.

Table 7. Habitat Types that Occur in the Pinyon-juniper Forest Cover Type

NAME	PA NUMBER	HT NUMBER
ABCO/GATR	riparian	51501
ABLA/VAMY-LIBO	3201	30401
PIEN/HESP	riparian	21101
PILE/ARPU	33020	100401
PILE/PIFI	33010	100501
PILE/QUAR	33020	100201
PILE/QUEM	33020	100301
PILE/QUHY	33030	100101
PINEN/QUHY	32030	90301
PINEN/QURU	32050	90201
PIPO/ARPU,ARPU	11420	82101
PIPO/MUMO	11330	80601
PIPO/POFE	11330	82301
PIPO/QUAR,BOGR	11411	81402
PIPO/QUAR,QUAR	11410	81401
PIPO/QUGA,SCSC	11215	80206
PIPO/QUHY	11220	81301
PIPO/QURU	11430	81201
PIPU/POPR	6030	41101
PIPU/SWSE	6010	40901
PSME/QUGA,QUGA	12140	70301
PSME/QUHY	12360	70801

Table 8. Habitat Types that Occur in the Ponderosa Pine Forest Cover Type

NAME	HT NUMBER	PA NUMBER
ABCO/ACGL,ACGL	1010	50401
ABCO/ARUV	1090	50601
ABCO/CAFO	1150	51301
ABCO/ELTR	1120	51101
ABCO/FEAR,FEAR	1040	50901
ABCO/GATR	riparian	51501
ABCO/HODU	260000	51201
ABCO/LAAR	1070	51401
ABCO/MUVI	1060	50801
ABCO/QUGA,FEAR	1052	50703
ABCO/QUGA,MUVI	1051	50704
ABCO/QUGA,QUGA	1050	50701
ABCO/Sparse	1020	50501
ABCO/VAMY	1100	50101
PIEN/EREX	4310	21001
PIEN/SECA,ABCO	4351	20502
PILE/ARPU	33020	100401
PILE/PIFI	33010	100501
PILE/QUAR	33020	100201
PILE/QUEM	33020	100301
PILE/QUHY	33030	100101
PINEN/MULO	32010	90101
PINEN/QUAR	32020	90401
PINEN/QUEM	32040	90501
PIPO/ACGR	undescribed	81601
PIPO/ARPU,ARPU	11420	82101
PIPO/ARPU,QUGA	11420	82102
PIPO/ARUV	11400	80101
PIPO/BOGR,ANHA	11032	80705
PIPO/BOGR,ARTR	11033	80706
PIPO/BOGR,BOGR	11030	80701
PIPO/BOGR,PIED	11030	80703
PIPO/BOGR,QUGA	11035	80704
PIPO/BOGR,SCSC	11031	80702
PIPO/Cinder	11032	82701
PIPO/COME	11320	82401
PIPO/FEAR,BOGR	11092	80304
PIPO/FEAR,DAPA	11091	80302
PIPO/FEAR,FEAR	11090	80301
PIPO/FEAR,QUGA	11093	80303
PIPO/JUMA	11470	81701
PIPO/MUMO	11330	80601
PIPO/MUVI,MUVI	11340	80501
PIPO/MUVI,QUGA	11341	80502
PIPO/MUVI-FEAR,BOGR	11391	80403
PIPO/MUVI-FEAR,MUVI-FEAR	11390	80401
PIPO/MUVI-FEAR,QUGA	11392	80402
PIPO/POFE	11330	82301
PIPO/POLO	11330	82201
PIPO/POPR	undescribed	81801
PIPO/QUAR,BOGR	11411	81402
PIPO/QUAR,QUAR	11410	81401
PIPO/QUEM	11440	81501
PIPO/QUGA,BOGR	11215	80207
PIPO/QUGA,FEAR	11211	80203
PIPO/QUGA,MULO	11212	80205
PIPO/QUGA,PIED	11213	80202
PIPO/QUGA,QUGA	11210	80201
PIPO/QUGA,SCSC	11215	80206
PIPO/QUGR,MULO	11361	82503
PIPO/QUGR,MUMO	11360	82502
PIPO/QUHY	11220	81301
PIPO/QURU	11430	81201
PIPO/QUUN,QUUN	11370	80801
PIPO/RIIN	11500	81101
PIPO/Unclassified	unclassified	80000
PIPU/ARUV	6080	40701
PIPU/CAFO	6060	40601
PIPU/FEAR	6090	40801
PSME/ARUV	12310	70701
PSME/BRCI	12320	70101
PSME/FEAR	12330	70501
PSME/HODU	12410	70901
PSME/MUMO	12340	70601
PSME/MUVI	12350	70401
PSME/QUAR	12430	71201
PSME/QUGA,FEAR	12141	70302
PSME/QUGA,HODU	12143	70304
PSME/QUGA,MUVI	12142	70303
PSME/QUGA,QUGA	12140	70301
PSME/QUHY	12360	70801
PSME/Sparse	12030	70201
PSME/Unclassified	unclassified	70000

Table 9. Habitat Types that Occur in the Mixed-species Group Forest Cover Types

NAME	PA NUMBER	HT NUMBER
ABCO/ACGL,ACGL	1010	50401
ABCO/ACGL,BERE	1011	50403
ABCO/ACGL,HODU	1012	50404
ABCO/ACGR,ACGR	1080	50201
ABCO/ARUV	1090	50601
ABCO/CAFO	1150	51301
ABCO/ELTR	1120	51101
ABCO/EREX	1030	50301
ABCO/FEAR,FEAR	1040	50901
ABCO/FEAR,POFE	1041	50902
ABCO/GATR	riparian	51501
ABCO/HODU	260000	51201
ABCO/JUMA	1140	51601
ABCO/LAAR	1070	51401
ABCO/MUVI	1060	50801
ABCO/QUGA,HODU	1054	50702
ABCO/QUGA,MUVI	1051	50704
ABCO/QUGA,QUGA	1050	50701
ABCO/RONE	1110	51001
ABCO/Sparse	1020	50501
ABCO/VAMY	1100	50101
ABLA/ACGL	3080	31201
ABLA/EREX	3080	30701
ABLA/JAAM	3320	31301
ABLA/Moss	3110	30201
ABLA/RUPA	3240	30601
ABLA/SABR	260000	31101
ABLA/VAMY	3200	30301
ABLA/VAMY-LIBO	3201	30401
ABLA/VAMY-RUPA	3202	30501
PIAR/FETH	23831	10101
PIAR/Scree	23804	10201
PIEN/ACGL	4300	20601
PIEN/ELTR	4320	20701
PIEN/EREX	4310	21001
PIEN/Moss	4060	20301
PIEN/SECA,ABCO	4351	20502
PIEN/SECA,ABLA	4350	20501
PIFL/ARUV	24030	60101
PIPO/MUVI,MUVI	11340	80501
PIPO/QUHY	11220	81301
PIPO/QURU	11430	81201
PIPO/RIIN	11500	81101
PIPU-PSME,VACA	6071	41301
PIPU/ARUV	6080	40701
PIPU/CAFO	6060	40601
PIPU/EREX	6070	40401
PIPU/FEAR	6090	40801
PIPU/FROV	6060	40501
PIPU/JUCO	6070	40201
PIPU/LIBO	6040	40101

NAME	PA NUMBER	HT NUMBER
PIPU/POPR	6030	41101
PIPU/SECA	6130	40301
PIPU/SWSE	6010	40901
PSME/ACGR	12390	71301
PSME/ARUV	12310	70701
PSME/BRCI	12320	70101
PSME/FEAR	12330	70501
PSME/HODU	12410	70901
PSME/MUVI	12350	70401
PSME/QUAR	12430	71201
PSME/QUGA,FEAR	12141	70302
PSME/QUGA,HODU	12143	70304
PSME/QUGA,MUVI	12142	70303
PSME/QUGA,QUGA	12140	70301
PSME/QUHY	12360	70801
PSME/QURU	12362	71001
PSME/Sparse	12030	70201
PSME/Unclassified	unclassified	70000

Table 10. Habitat Types that Occur in the Spruce-fir Forest Cover Type

NAME	PA NUMBER	HT NUMBER
ABLA/EREX	3080	30701
ABLA/JUCO	3090	30901
ABLA/LAAR	3310	31001
ABLA/MECI	3060	30101
ABLA/Moss	3110	30201
ABLA/RUPA	3240	30601
ABLA/SABR	260000	31101
ABLA/SES	3300	30801
ABLA/VAMY	3200	30301
ABLA/VAMY-LIBO	3201	30401
ABLA/VAMY-RUPA	3202	30501
PIAR/FETH	23831	10101
PIEN/ACGL	4300	20601
PIEN/CAFO	3370	20901
PIEN/ELTR	4320	20701
PIEN/EREX	4310	21001
PIEN/HESP	riparian	21101
PIEN/Moss	4060	20301
PIEN/SABR	260000	20801
PIEN/SECA,ABCO	4351	20502
PIEN/SECA,ABLA	4350	20501
PIEN/VAMY	4360	20201
PIEN/VAMY/POPU,PIEN	4151	20101
PSME/Unclassified	unclassified	70000

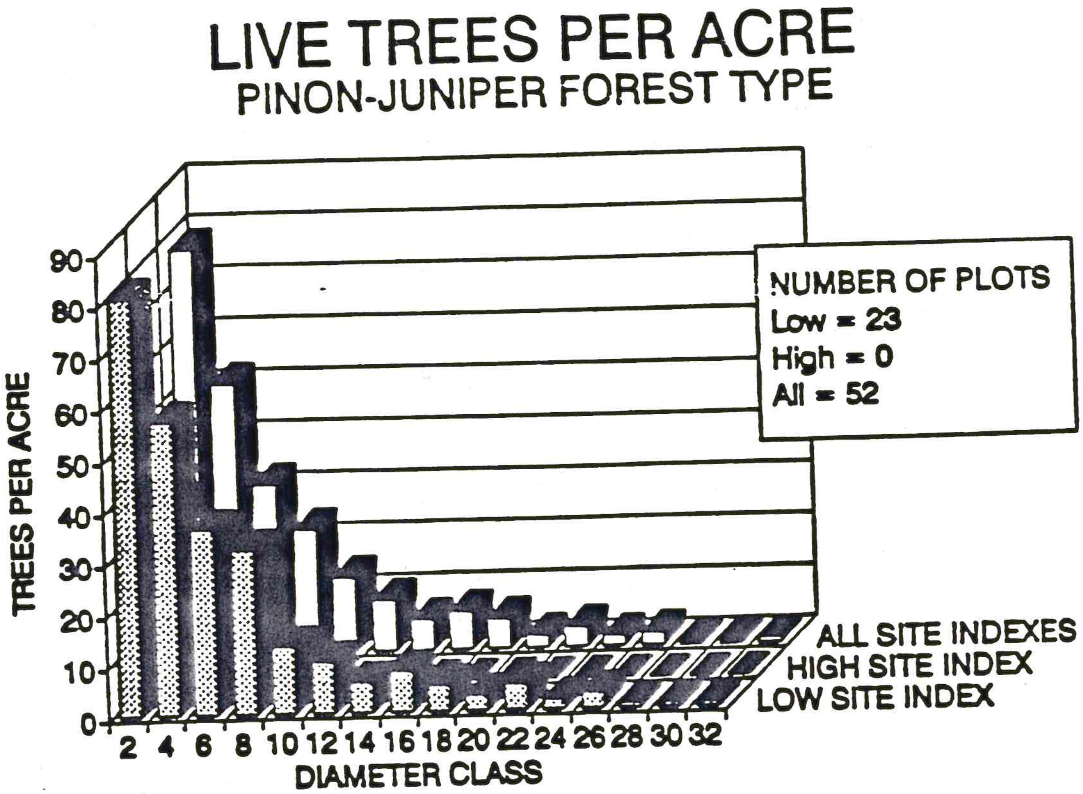

Figure 1. Number of live trees per acre in pinyon-juniper forest cover types displayed in 2-inch diameter classes, starting at 2 inches.

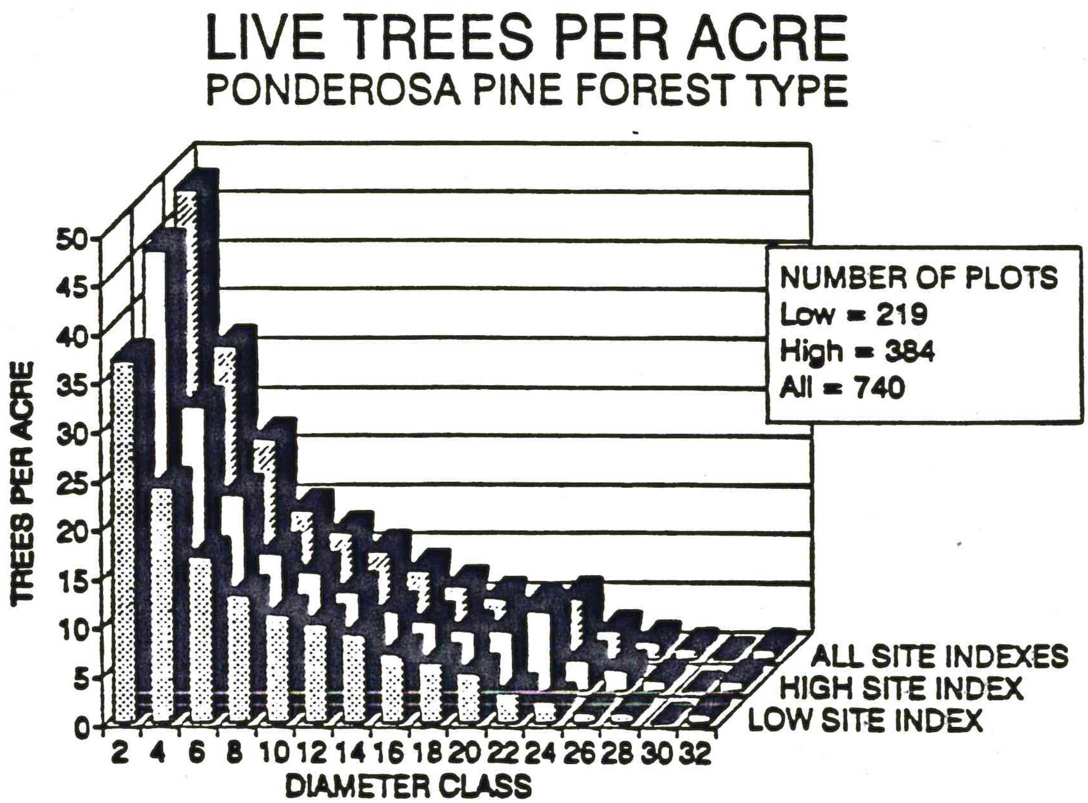

Figure 2. Number of live trees per acre in ponderosa pine forest cover types displayed in 2-inch diameter classes, starting at 2 inches.

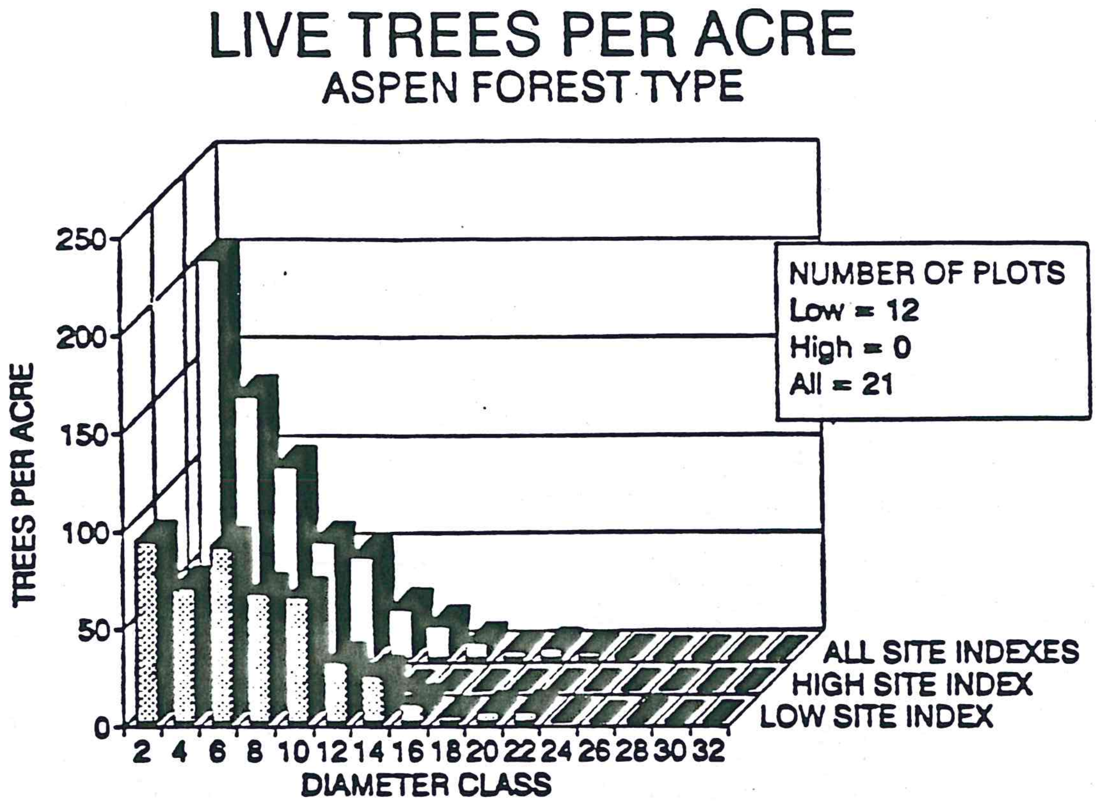

Figure 3. Number of live trees per acre in aspen forest cover types displayed in 2-inch diameter classes, starting at 2 inches.

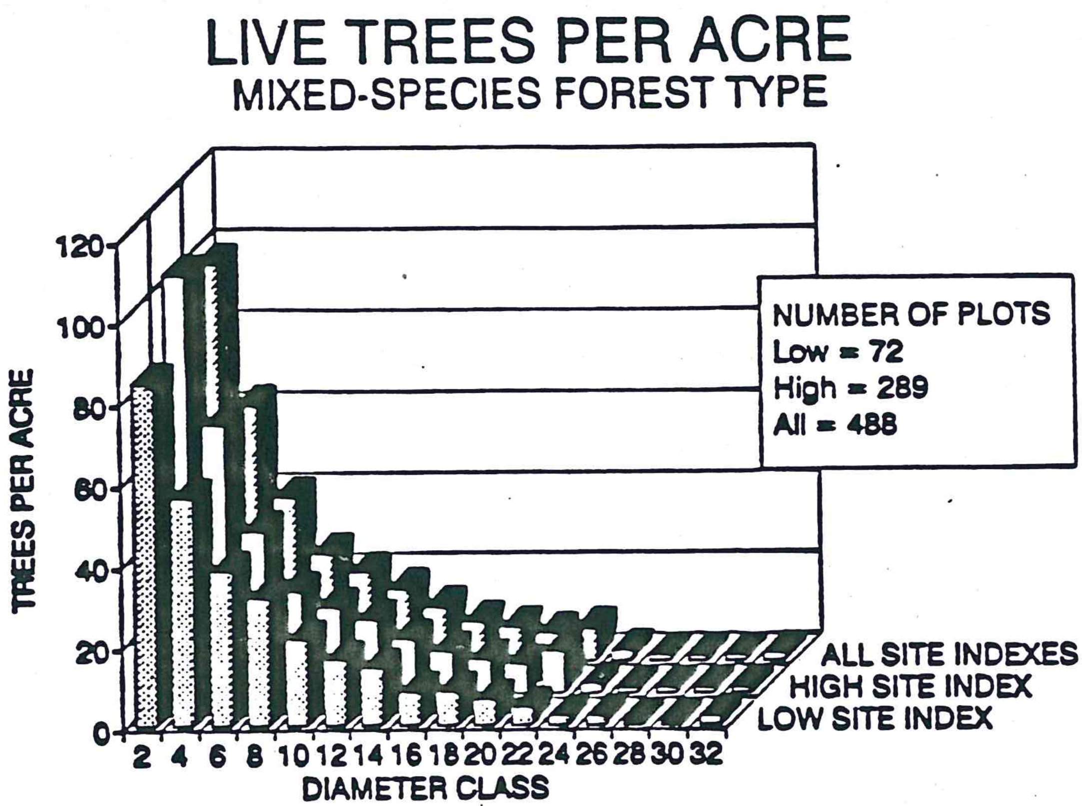

Figure 4. Number of live trees per acre in mixed-species forest cover types displayed in 2-inch diameter classes, starting at 2 inches.

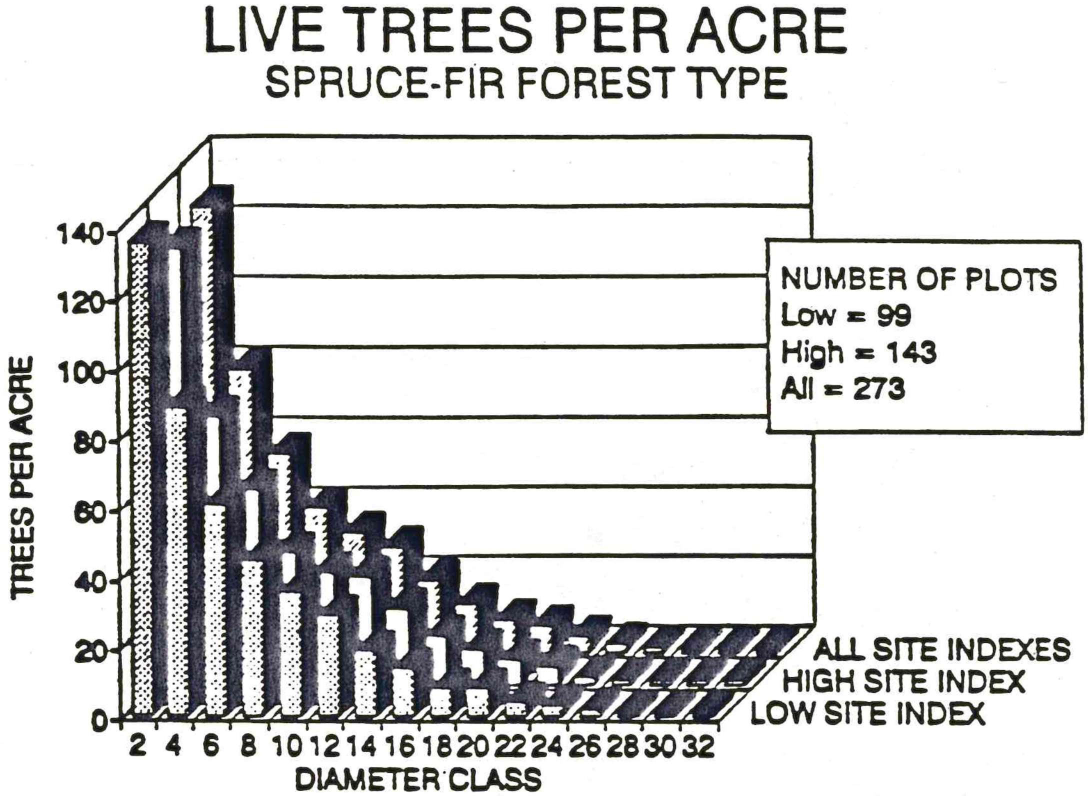

Figure 5. Number of live trees per acre in spruce-fir forest cover types displayed in 2-inch diameter classes, starting at 2 inches.

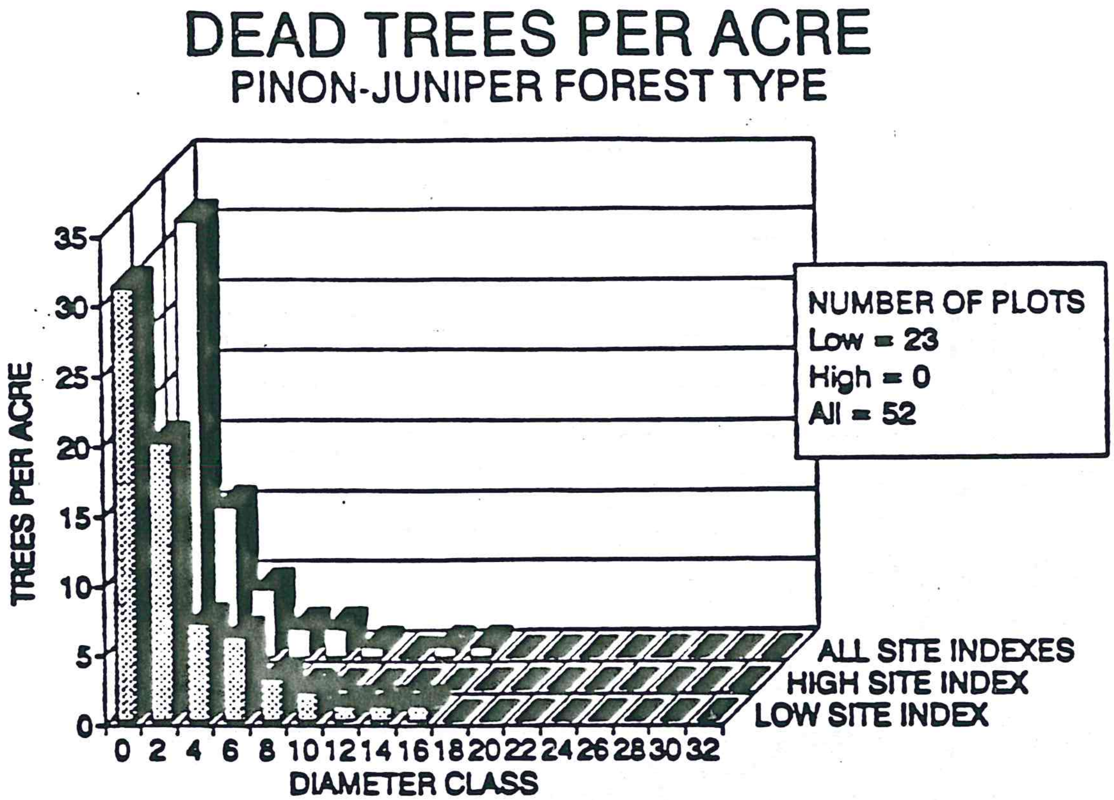

Figure 6. Number of dead trees per acre in pinyon-juniper forest cover types displayed in 2-inch diameter classes.

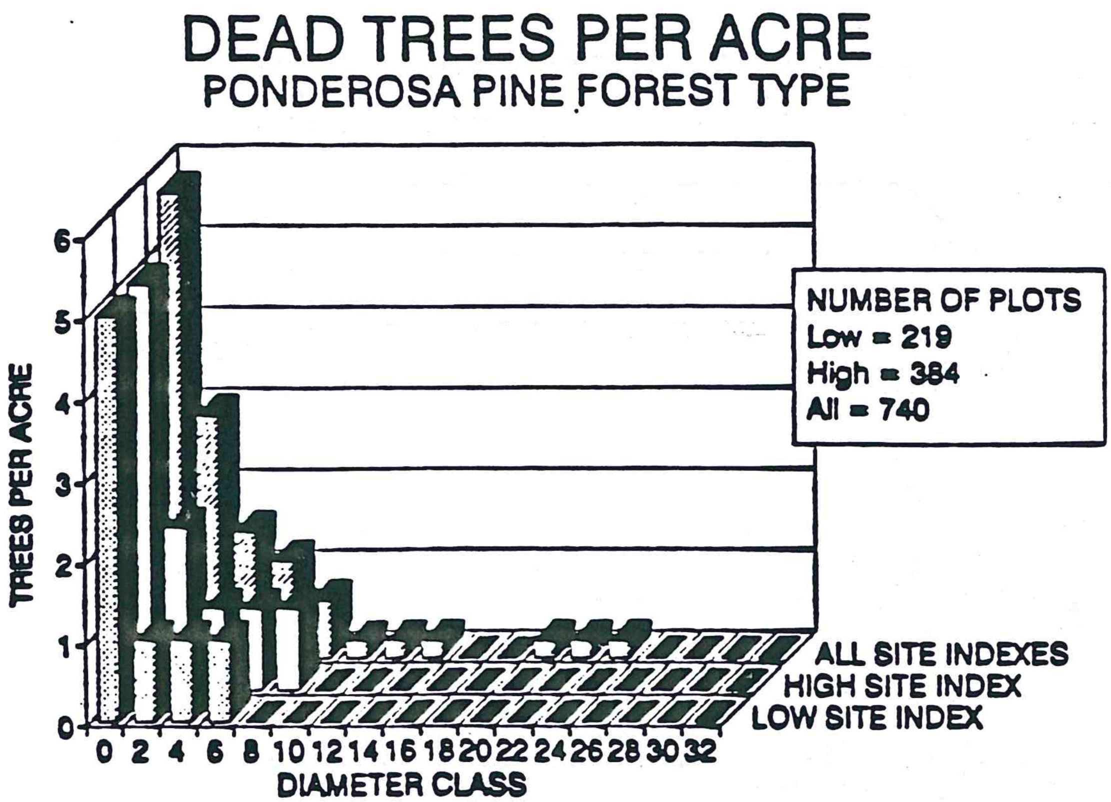

Figure 7. Number of dead trees per acre in ponderosa pine forest cover types displayed in 2-inch diameter classes.

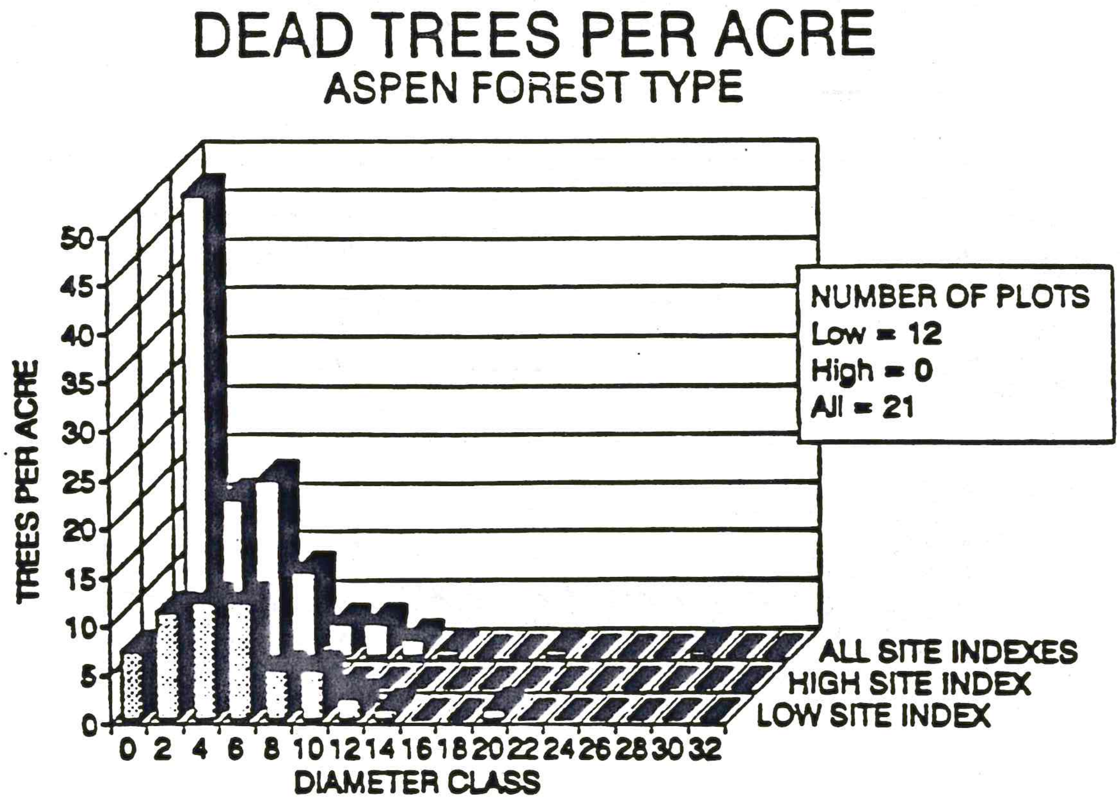

Figure 8. Number of dead trees per acre in aspen forest cover types displayed in 2-inch diameter classes.

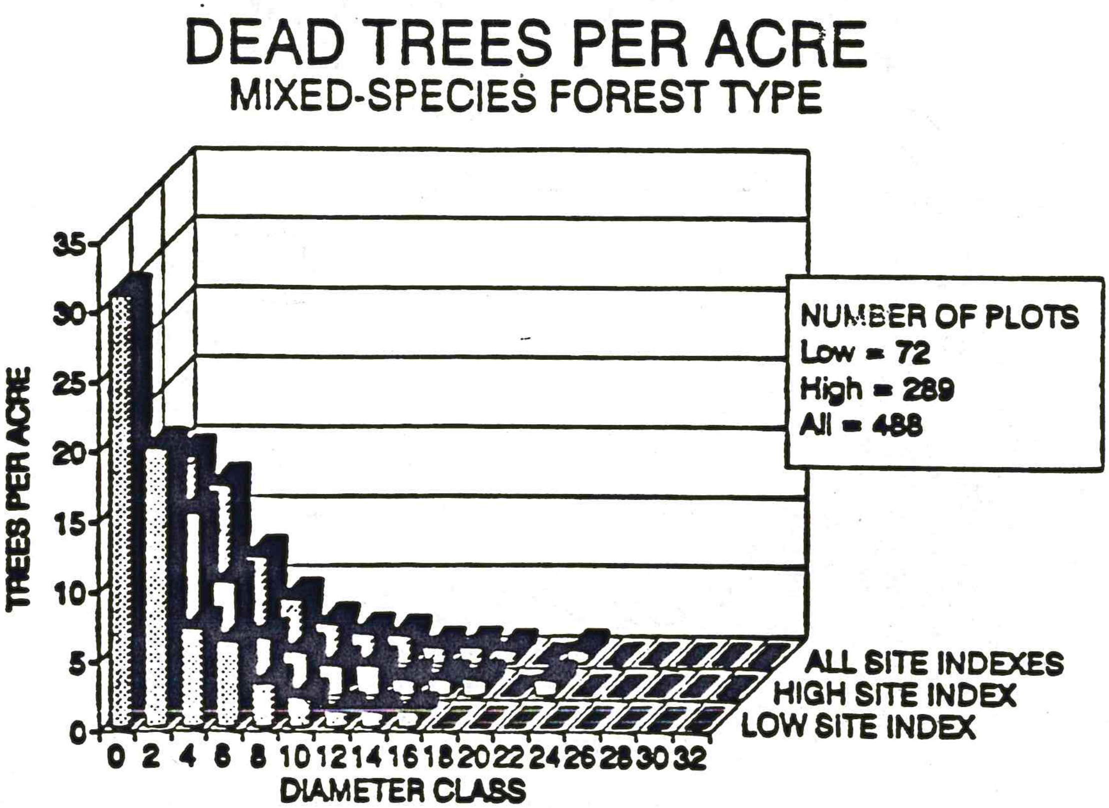

Figure 9. Number of dead trees per acre in mixed-species forest cover types displayed in 2-inch diameter classes.

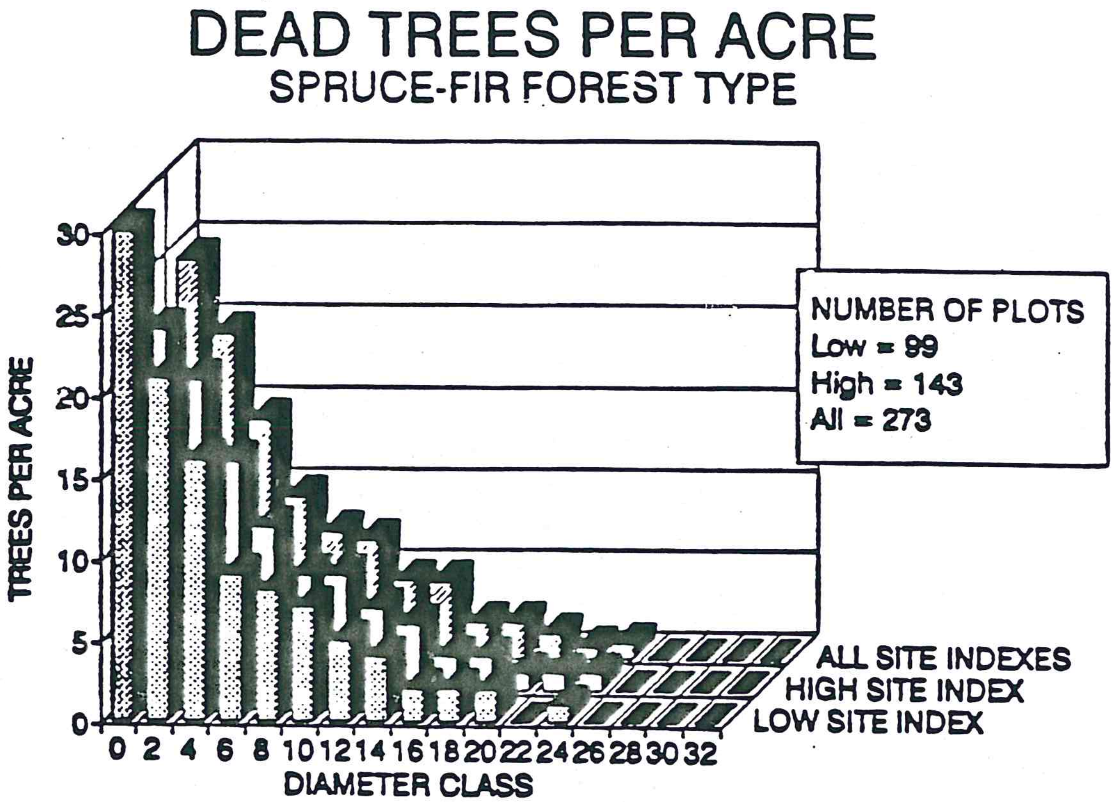

Figure 10. Number of dead trees per acre in spruce-fir forest cover types displayed in 2-inch diameter classes.

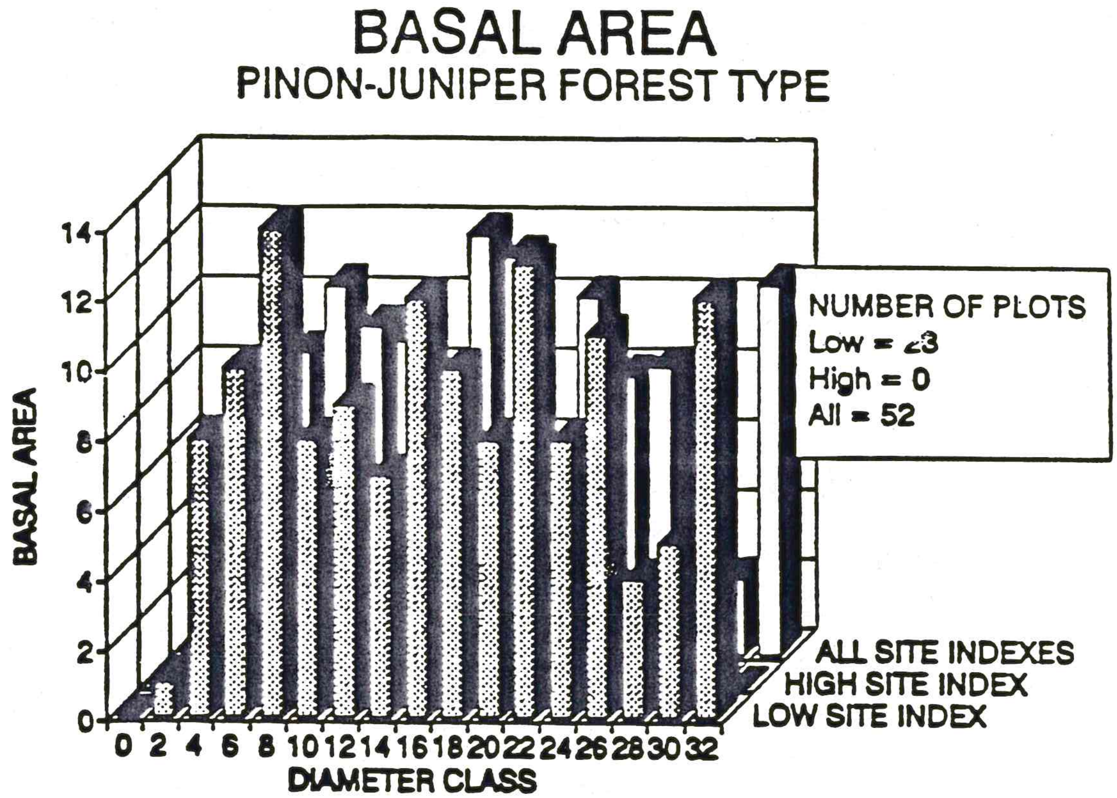

Figure 11. Basal area of pinyon-juniper forest cover types displayed in 2-inch diameter classes.

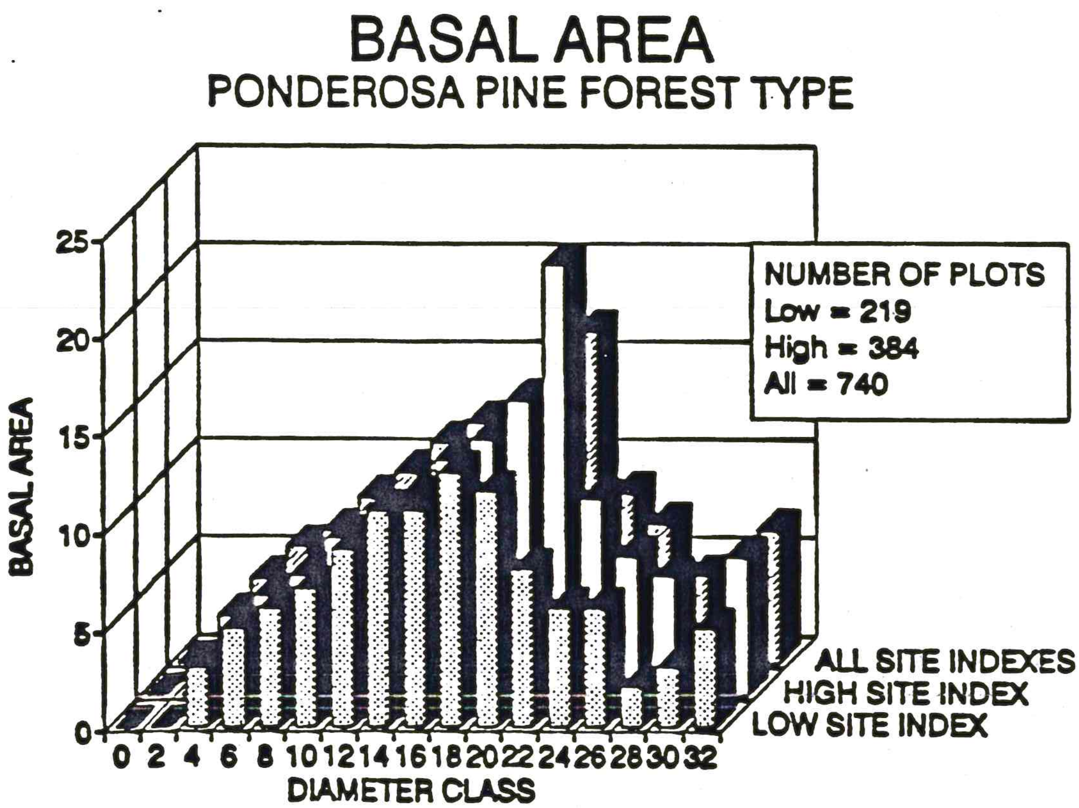

Figure 12. Basal area of ponderosa pine forest cover types displayed in 2-inch diameter classes.

BASAL AREA
ASPEN FOREST TYPE

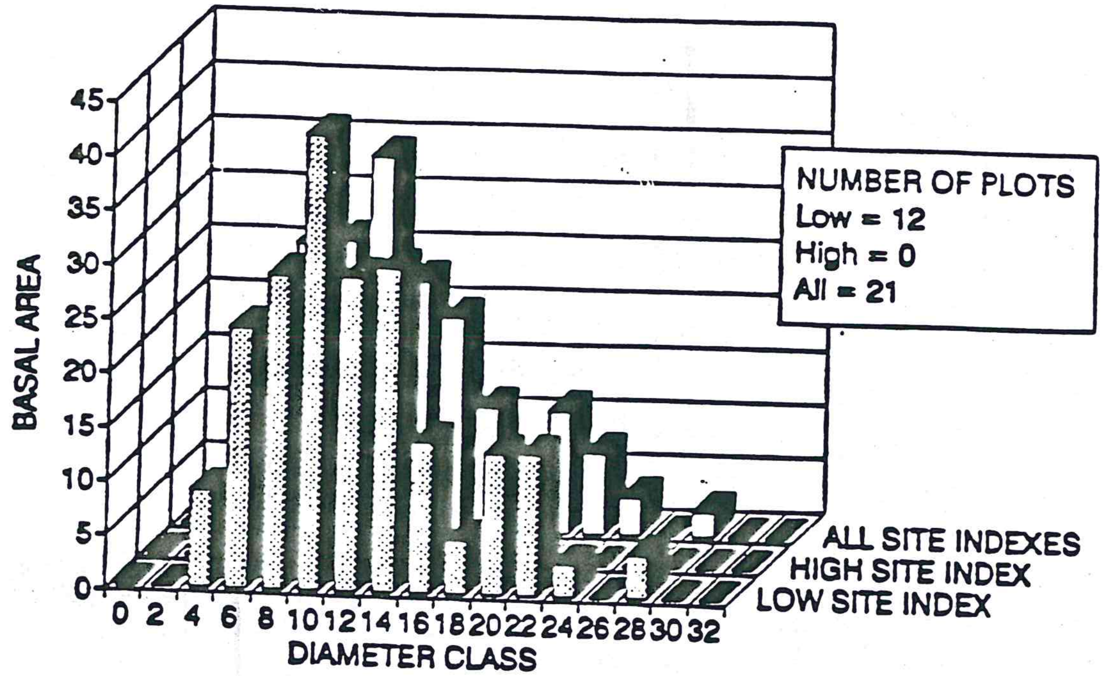

Figure 13. Basal area of aspen forest cover types displayed in 2-inch diameter classes.

BASAL AREA
MIXED-SPECIES FOREST TYPE

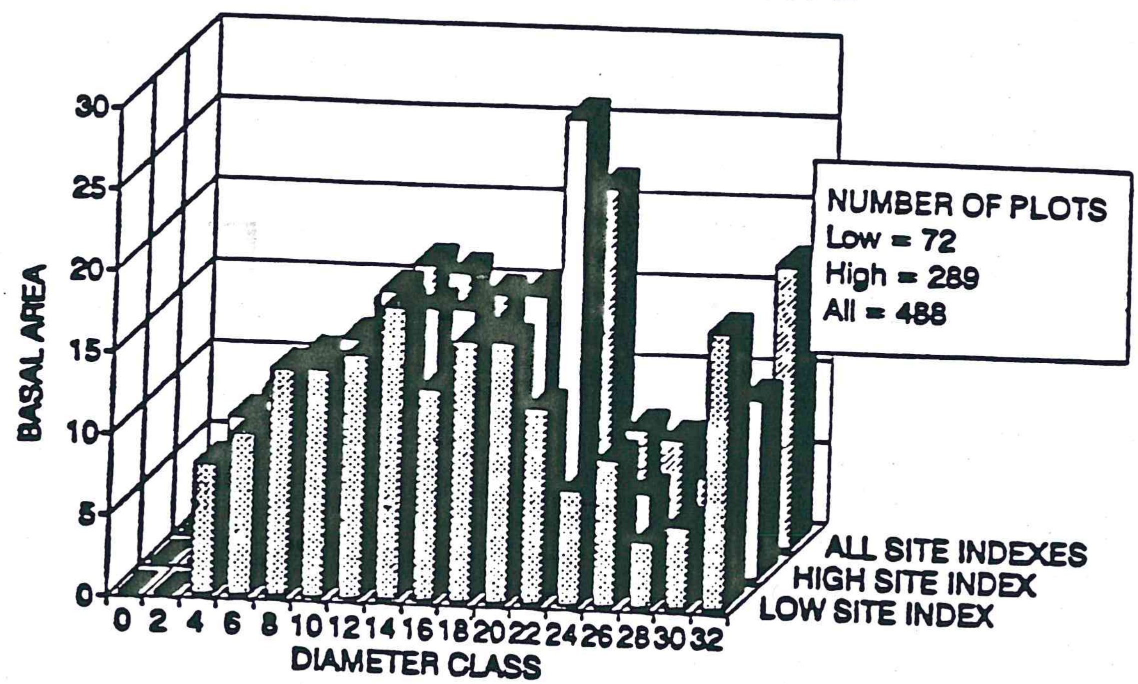

Figure 14. Basal area of mixed-species forest cover types displayed in 2-inch diameter classes.

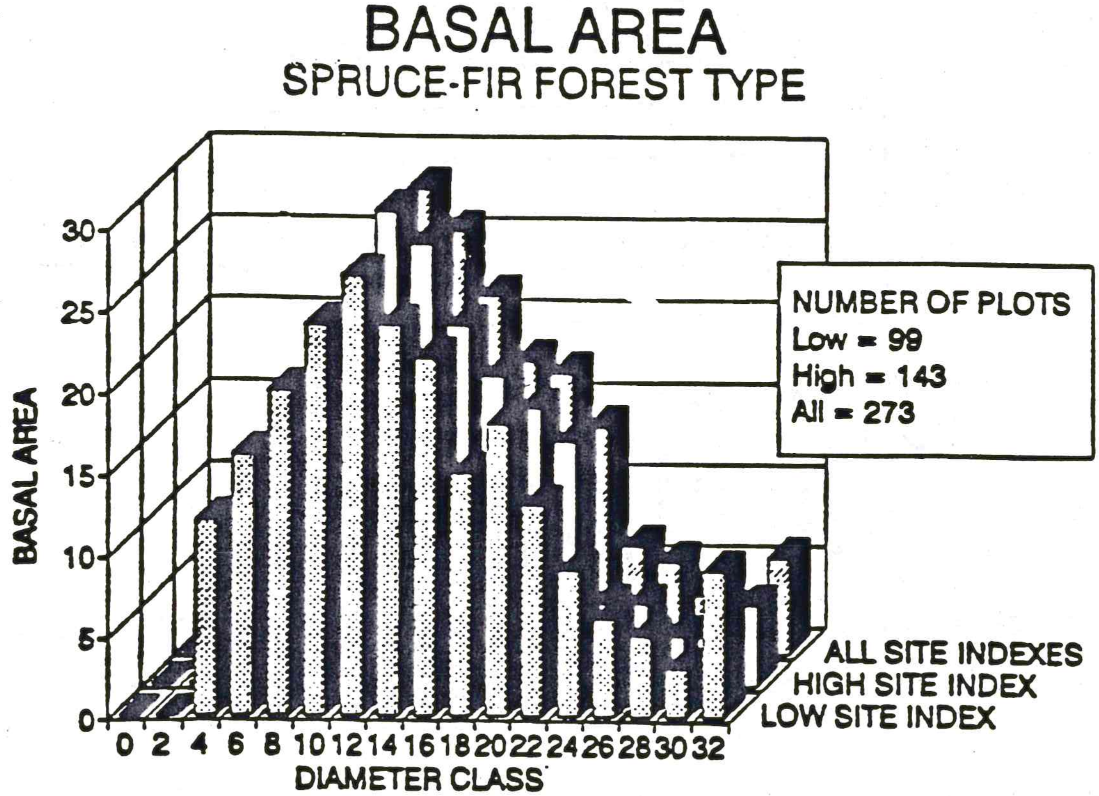

Figure 15. Basal area of spruce-fir forest cover types displayed in 2-inch diameter classes.