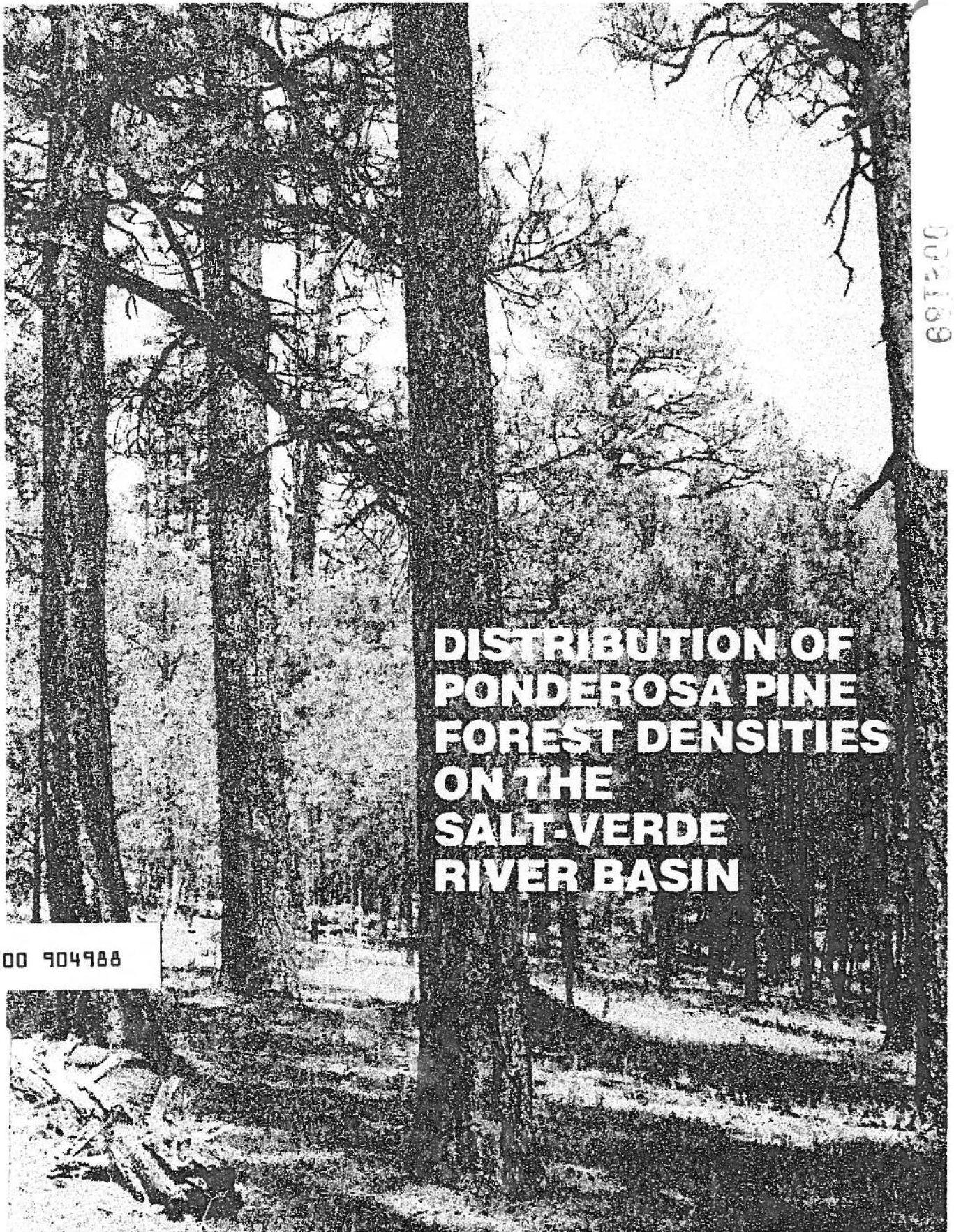


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Technical Bulletin 227



**DISTRIBUTION OF
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FOREST DENSITIES
ON THE
SALT-VERDE
RIVER BASIN**

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Agricultural Experiment Station
The University of Arizona

by Peter F. Ffolliott
and Rhey M. Solomon

NORTHERN ARIZONA UNIVERSITY

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Technical Bulletin 227

Distribution of Ponderosa Pine Forest Densities on the Salt-Verde River Basin

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Contents

	Page
Introduction	1
Methodology	2
Presentation of Survey Information	2
Applications of Survey Information	2
Literature Cited	3
Tables	4

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Introduction

Identification of the proportions of forested areas that support given minimum timber densities which, in turn, may affect the yield of natural resource products and uses should be quantified to assess the operational feasibility of proposed forest management systems. Estimates of *average* timber densities, commonly presented as primary summaries of timber inventories, may not provide complete knowledge of vegetative characteristics, particularly with frequently "skewed" timber populations.

An important area that supplies natural resource products and uses to central Arizona is the ponderosa pine forest type on the Salt-Verde River Basin (Fig. 1). This area furnishes a diversity of primary wood products, forage for domestic livestock and wildlife, water for agricultural, municipal, and industrial developments, and many forms of recreational and aesthetic uses.

The objective of this report is to provide information to land management planners on the proportions of the Salt-Verde River Basin that support given minimum timber densities.¹ This information will supplement existing descriptions of ponderosa pine forests on the Basin. Specific information presented is the proportions of national forest and Indian tribal lands within the Basin that support minimum timber basal area levels. Basal area² was selected as the expression of timber overstory density because it is easily determined in the field, easily converted to other expressions of forest density, and many multiple use relationships have already been developed with basal area as the independent variable (Ffolliott and Worley 1965).

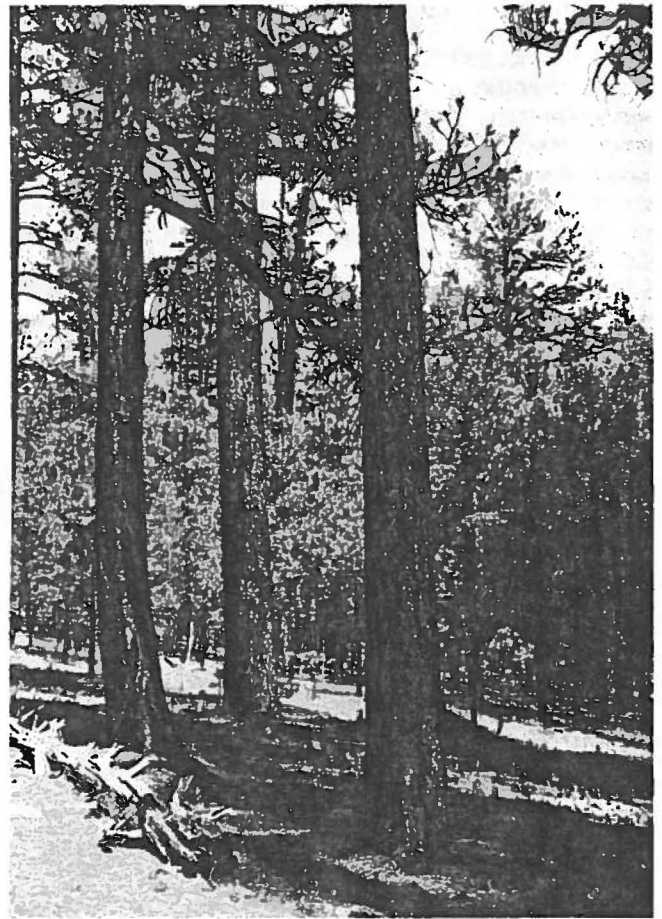


Figure 1. Ponderosa pine type on the Salt-Verde River Basin in north-central Arizona.

¹A similar report has been prepared to provide basic survey information on physiographic characteristics of the ponderosa pine type on the Salt-Verde River Basin (Ffolliott *et al.* 1972). Also, a report is being developed on the climatic characteristics.

²Basal area is defined as the total cross-sectional area in square feet of all tree boles measured 4½ feet above the ground, expressed on a per unit-area basis.

Methodology

The methods employed involved the assessment of timber inventory data provided by the USDA Forest Service and the USDI Bureau of Indian Affairs.³ In essence, these source data summarized estimates of basal area, by tree species and size classes, on primary sampling units included in the timber inventories on national forest and Indian tribal lands within the Salt-Verde River Basin.

The primary sampling units on national forest lands were 10-point clusters, with basal area estimated at each sampling point by applying point sampling techniques with a basal area factor of 40. On Indian tribal lands, individual sample points comprised the primary sampling units, with basal area estimated by point sampling techniques employing a basal area factor of 10. The sampling designs and intensities were in accordance with the standard inventory procedures followed by the respective agencies. The number of primary sampling units analyzed in this survey, by management jurisdiction, were:

National Forests	
Apache-Sitgreaves	77
Coconino	109
Kaibab	89
Prescott	46
Tonto	<u>151</u>
Total	472
Indian Tribal Lands	613

For each management jurisdiction, and considering each tree species found in the ponderosa pine forest type on the Salt-Verde River Basin, the following analytic procedure was implemented for the following size classes: all size classes combined, merchantable (at least 11.0 inches diameter), and submerchantable (5.0 to 10.9 inches diameter). Estimates of basal area on each management jurisdiction were aggregated by selected intervals. These aggregations assumed the properties of, and were considered to be, frequency functions (Brunk 1965). Then, cumulative distribution functions were developed from the frequency functions. The cumulative distribution functions were described as continuous from the right and, therefore, can be considered as exceedance functions.

³The authors acknowledge the assistance of Paul F. O'Connell, Rocky Mountain Forest and Range Experiment Station (USDA Forest Service), Tucson, Arizona, and Bud Mast, Fort Apache Indian Agency (USDI Bureau of Indian Affairs), Whiteriver, Arizona, in obtaining the timber inventory data necessary for this survey.

It was assumed that the sampling of basal area within each management jurisdiction was unbiased. Therefore, the proportions of a jurisdiction that support given estimates of minimum timber overstory basal area levels can be estimated from the proportions of the sampling units that support corresponding minimum basal area levels.

Presentation of Survey Information

To facilitate data presentation, the information has been organized to describe the proportions of each management jurisdiction recognized that support given estimates of minimum timber basal area levels by tree species and size classes. This information is presented in Tables 1 through 37.

Unfortunately, differences in timber inventory data collected on the national forest and Indian tribal lands prevented a pooling of these data. Also, data summaries representative of the tree species found in the ponderosa pine type and of all size classes collectively were not possible on the Indian tribal lands.

Applications of Survey Information

The basic information provided in this report can be used by land management planners to assist in the assessment of potential productivities and uses of natural resources. It is assumed that the proportion of a jurisdiction unit that currently supports a minimum timber basal area level which, in turn, corresponds to the basal area level prescribed by the management system will, subsequently, represent the proportion of the unit that can be subjected to the management system (Ffolliott and Worley 1973).

Regardless of what a management system is designed to accomplish, the application of information such as presented in this report may help to evaluate management potential and prescribe management feasibility. A timber manager, for example, might ask, "What is the extent of a timber density level considered to be the minimum for profitable harvesting?" A range specialist may ask, "What proportion of a jurisdiction, unit supports a timber density level in excess of the level considered maximum to allow acceptable forage production for allotment management?" A hydrologist might ask, "What is the distribution of timber density levels that relate to specific accumulation and melt characteristics?" An economist interested in direct

costs of management system implementation may ask, "How much of a forest needs to be treated, and what intensity does the treatment need to be applied to bring a jurisdiction unit to a pre-described timber density level?"

A decision as to the feasibility of imposing a management system (i.e., reducing timber densities, removing timber completely, etc.) to meet a production or use objective regarding a natural resource base can be aided by knowledge of the survey information presented herein. For example, suppose that a management system calls for a uniform reduction of timber densities to a level assumed to be "optimum" in terms of natural resource production and use. However, an exceedance function developed for the jurisdiction unit in question may reveal that only, say, 40 percent of the area could meet the timber basal area level prescribed by the management system. A decision may then need to be made relative to the feasibility of implementing the system. Possibly, the original prescription could be discarded in favor of one that would place a larger proportion of the unit under management, such as reducing the timber densities to a level that is less than the assumed "optimum." Unfortunately, this alternative may result in a lower potential for natural resource production and use. However, due to the greater proportion of the area subjected to management, the outcome could be more favorable in the longrun. Obviously, the final decision must be a compromise between obtaining the maximum potential and extending the management system to the largest possible proportion of the jurisdiction unit.

Literature Cited

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- Ffolliott, Peter F., and David P. Worley. 1965.** An overstory inventory system for multiple use evaluations. USDA Forest Service Research Paper RM-17, 13 p.
- Ffolliott, Peter F. 1973.** Forest stocking equations: their development and applications. USDA Forest Service Research Paper RM-102, 8 p.
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Tables

Table 1. National Forest land on the Salt-Verde River Basin stocked with timber species to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
0	100	100	100
20	96.0	91.5	77.5
40	86.7	65.9	42.4
60	71.4	38.1	16.5
80	50.4	18.0	8.0
100	33.1	8.7	2.5
120	19.5	3.2	0.8
140	10.4	2.1	0.2
160	5.3	1.5	0.2
180	3.4	1.1	0.2
200	1.5	0.4	0
220	0.4	0	0
240	0.2	0	0
260+	0	0	0

Table 2. National Forest land on Salt-Verde River Basin stocked with ponderosa pine to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
0	100	100	100
20	86.7	79.2	55.7
40	66.5	41.9	24.6
60	42.6	17.6	10.0
80	25.2	5.3	4.0
100	14.0	1.3	1.5
120	5.9	0.6	0.4
140	3.0	0.2	0
160	1.5	0.2	0
180	0.6	0	0
200	0.4	0	0
220	0.2	0	0
240	0.2	0	0
260+	0	0	0

Table 3. National Forest land on the Salt-Verde River Basin stocked with Douglas-fir to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
0	100	100	100
20	10.8	7.4	5.3
40	5.9	3.4	0
60	2.1	1.7	0
80	1.3	0.8	0
100	0.2	0.2	0
120	0.2	0.2	0
140	0.2	0.2	0
160	0.2	0.2	0
180+	0	0	0

Table 4. National Forest land on the Salt-Verde River Basin stocked with white fir to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
0	100	100	100
20	3.4	2.8	0.8
40	1.7	1.1	0
60	0.4	0.4	0
80	0.4	0.2	0
100+	0	0	0

Table 5. National Forest land on the Salt-Verde River Basin stocked with corkbark fir to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
0	100	100	100
20	1.1	0.8	0.2
40	0.4	0.2	0
60	0.2	0.2	0
80+	0	0	0

Table 6. National Forest land on the Salt-Verde River Basin stocked with aspen to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
0	100	100	100
20	5.7	3.6	3.6
40	3.4	1.5	2.1
60	2.3	0.4	0.8
80	1.5	0.4	0.2
100	1.3	0	0.2
120	1.1	0	0
140	0.4	0	0
160	0.4	0	0
180	0.2	0	0
200	0.2	0	0
220	0.2	0	0
240	0.2	0	0
260+	0	0	0

Table 7. Apache-Sitgreaves National Forest land on the Salt-Verde River Basin stocked with timber species to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
0	100	100	100
20	98.7	98.7	74.0
40	96.2	83.1	39.0
60	76.9	61.0	5.2
80	62.8	37.7	4.0
100	49.4	26.0	1.3
120	33.3	9.1	1.3
140	21.8	6.5	1.3
160	12.8	3.9	1.3
180	7.7	1.3	1.3
200	3.8	0	0
220+	0	0	0

Table 8. Apache-Sitgreaves National Forest land on the Salt-Verde River Basin stocked with ponderosa pine to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
0	100	100	100
20	82.1	82.1	32.1
40	64.1	53.8	11.5
60	38.5	25.6	0
80	21.8	10.3	0
100	10.3	1.3	0
120+	0	0	0

Table 9. Apache-Sitgreaves National Forest land on the Salt-Verde River Basin stocked with Douglas-fir to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
0	100	100	100
20	41.0	33.3	15.4
40	28.2	19.2	0
60	11.5	10.3	0
80	7.7	5.1	0
100	1.3	1.3	0
120	1.3	1.3	0
140	1.3	1.3	0
160	1.3	1.3	0
180+	0	0	0

Table 10. Apache-Sitgreaves National Forest land on the Salt-Verde River Basin stocked with white fir to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
0	100	100	100
20	15.4	12.8	0
40	6.4	5.1	0
60	1.3	1.3	0
80	1.3	1.3	0
100+	0	0	0

Table 11. Apache-Sitgreaves National Forest land on the Salt-Verde River Basin stocked with corkbark fir to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
0	100	100	100
20	2.6	2.6	1.3
40	1.3	0	0
60+	0	0	0

Table 12. Apache-Sitgreaves National Forest land on the Salt-Verde River Basin stocked with aspen to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
0	100	100	100
20	28.2	15.4	15.4
40	14.1	5.1	7.7
60	7.7	0	3.8
80	2.6	0	2.6
100	2.6	0	2.6
120	1.3	0	1.3
140	1.3	0	1.3
160	1.3	0	1.3
180+	0	0	0

Table 13. Coconino National Forest land on the Salt-Verde River Basin stocked with timber species to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
0	100	100	100
20	91.7	87.2	73.3
40	83.3	61.5	49.5
60	72.2	39.4	25.7
80	50.9	18.3	15.6
100	38.9	10.1	2.8
120	21.3	4.6	0
140	13.0	3.7	0
160	6.5	2.8	0
180	5.6	2.8	0
200	2.8	1.8	0
220	1.9	0.9	0
240	0.9	0	0
260+	0	0	0

Table 14. Coconino National Forest land on the Salt-Verde River Basin stocked with ponderosa pine to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
0	100	100	100
20	84.4	78.0	66.0
40	76.1	48.6	36.7
60	56.9	23.8	17.4
80	35.8	8.3	10.1
100	23.9	3.7	2.8
120	15.6	1.8	0
140	6.4	0.9	0
160	2.8	0.9	0
180	1.8	0	0
200	0.9	0	0
220	0.9	0	0
240	0.9	0	0
260+	0	0	0

Table 15. Coconino National Forest land on the Salt-Verde River Basin stocked with Douglas-fir to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
0	100	100	100
20	3.7	1.8	1.8
40	1.8	0	0
60+	0	0	0

Table 16. Coconino National Forest land on the Salt-Verde River Basin stocked with white fir to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
0	100	100	100
20	0.9	0.9	0.9
40	0.9	0	0
60+	0	0	0

Table 17. Coconino National Forest land on the Salt-Verde River Basin stocked with corkbark fir to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
0	100	100	100
20	2.8	1.8	0
40	0.9	0.9	0
60+	0	0	0

Table 18. Coconino National Forest land on the Salt-Verde River Basin stocked with aspen to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
0	100	100	100
20	3.7	3.7	3.7
40	3.7	3.7	3.7
60	3.7	2.8	0.9
80	3.7	2.8	0
100	3.7	0	0
120	3.7	0	0
140	0.9	0	0
160	0.9	0	0
180	0.9	0	0
200	0.9	0	0
220	0.9	0	0
240+	0	0	0

Table 19. Kaibab National Forest land on the Salt-Verde River Basin stocked with timber species to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
0	100	100	100
20	97.7	91.0	67.4
40	78.7	53.9	25.8
60	55.1	19.1	10.1
80	28.1	5.6	2.2
100	12.4	1.1	2.2
120	5.6	1.1	2.2
140	4.5	0	0
160	2.2	0	0
180	1.1	0	0
200	1.1	0	0
220+	0	0	0

Table 20. Kaibab National Forest land on the Salt-Verde River Basin stocked with ponderosa pine to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
0	100	100	100
20	95.5	87.6	57.3
40	67.4	47.2	18.0
60	39.3	15.7	7.9
80	20.2	4.5	2.2
100	11.2	1.1	2.2
120	5.6	1.1	2.2
140	4.5	0	0
160	2.2	0	0
180	1.1	0	0
200	1.1	0	0
220+	0	0	0

Table 21. Kaibab National forest land on the Salt-Verde River Basin stocked with Douglas-fir to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
NO PLOTS STOCKED			

Table 22. Kaibab National Forest land on the Salt-Verde River Basin stocked with white fir to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
NO PLOTS STOCKED			

Table 23. Kaibab National Forest land on the Salt-Verde River Basin stocked with corkbark fir to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
NO PLOTS STOCKED			

Table 24. Kaibab National Forest land on the Salt-Verde River Basin stocked with aspen to minimum area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
0	100	100	100
20	1.1	1.1	1.1
40	1.1	0	1.1
60	1.1	0	1.1
80	1.1	0	0
100+	0	0	0

Table 25. Prescott National Forest land on the Salt-Verde River Basin stocked with timber species to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
0	100	100	100
20	95.7	84.8	82.6
40	71.7	52.2	43.5
60	63.0	32.6	17.4
80	47.8	10.9	6.5
100	28.2	2.2	2.2
120	17.4	0	0
140	6.5	0	0
160	2.2	0	0
180+	0	0	0

Table 26. Prescott National Forest land on the Salt-Verde River Basin stocked with ponderosa pine to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
0	100	100	100
20	82.6	71.7	56.5
40	58.7	41.3	21.7
60	43.5	17.4	6.5
80	23.9	4.3	4.3
100	13.0	0	2.2
120	6.5	0	0
140	4.3	0	0
160	2.2	0	0
180+	0	0	0

Table 27. Prescott National Forest land on the Salt-Verde River Basin stocked with Douglas-fir to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
NO PLOTS STOCKED			

Table 28. Prescott National Forest land on the Salt-Verde River Basin stocked with white fir to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
NO PLOTS STOCKED			

Table 29. Prescott National Forest land on the Salt-Verde River Basin stocked with corkbark fir to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
NO PLOTS STOCKED			

Table 30. Prescott National Forest land on the Salt-Verde River Basin stocked with aspen to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
NO PLOTS STOCKED			

Table 31. Tonto National Forest land on the Salt-Verde River Basin stocked with timber species to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
0	100	100	100
20	96.7	93.3	87.3
40	93.3	71.3	48.7
60	80.0	38.0	19.3
80	57.3	16.7	8.7
100	34.7	4.7	2.0
120	20.0	0.7	0.7
140	7.3	0	0
160	3.3	0	0
180	2.0	0	0
200 +	0	0	0

Table 32. Tonto National Forest land on the Salt-Verde River Basin stocked with ponderosa pine to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
0	100	100	100
20	86.7	76.0	59.3
40	62.7	28.0	27.3
60	36.0	10.0	12.0
80	22.7	1.3	2.7
100	10.7	0	0.7
120	2.0	0	0
140	0.7	0	0
160	0.7	0	0
180 +	0	0	0

Table 33. Tonto National Forest land in the Salt-Verde River Basin stocked with Douglas-fir to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
0	100	100	100
20	10.0	4.7	7.3
40	2.7	0.7	0
60	0.7	0	0
80 +	0	0	0

Table 34. Tonto National Forest land in the Salt-Verde River Basin stocked with white fir to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
0	100	100	100
20	2.0	1.3	2.0
40	1.3	0.7	0
60	0.7	0.7	0
80	0.7	0	0
100 +	0	0	0

Table 35. Tonto National Forest land on the Salt-Verde River Basin stocked with corkbark fir to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
NO PLOTS STOCKED			

Table 36. Tonto National Forest land on the Salt-Verde River Basin stocked with aspen to minimum basal area levels.

Basal Area Level	All Size Classes	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent	percent
NO PLOTS STOCKED			

Table 37. Indian tribal lands on the Salt-Verde River Basin stocked with timber species to minimum basal area levels.

Basal Area Level	Merchantable Size Classes	Submerchantable Size Classes
sq. ft./acre	percent	percent
0	100	100
20	99.4	95.4
40	97.7	88.1
60	95.6	77.2
80	92.3	65.1
100	87.8	55.0
120	79.9	45.2
140	71.3	36.4
160	62.5	29.4
180	56.9	24.3
200	50.2	18.6
220	43.2	13.9
240	36.7	10.3
260 +	30.8	8.5