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David R. Betters and Ruth F. Woods

*ABSTRACT—In the Rocky Mountains, many stands of quaking aspen (*Populus tremuloides *Michx.) are uneven aged. This age structure leads to suppression of the intolerant understory. In plots in northwestern Colorado, d.b.h. and height of suppressed trees ranged from 22 to 24 percent and 25 to 28 percent, respectively, less than for dominant and codominant trees. The percentage of suppressed trees that were rotten was in some cases more than double that of the overstory.*

Aspen is a highly intolerant species usually growing in even-aged stands. In the Lake States, most pure aspen stands are even aged and successional (Barrett 1962). In the Rocky Mountains, aspen also occurs in even-aged stands, but it sometimes develops an uneven-aged structure as the old canopy breaks up and scattered root suckers develop (Barrett 1962, Jones 1973). The extent of these uneven- or many-aged stands is not known. In a recent study of decay losses in aspen, however, Hinds and Wengert (1977) found many uneven-aged stands in a sample that covered five national forests in Colorado.

It is not commonly known that these conditions exist in the Rocky Mountains, though the uneven-aged nature of some aspen stands was observed many years ago (Fetherolf 1917, Baker 1925). Under certain conditions Rocky Mountain aspen perpetuates itself without a major disturbance like fire or cutting, and in some circumstances it can be a de facto climax type (Mueggler 1976)—a situation that can lead to an uneven-aged stand structure.

Few studies have been made of the effect of uneven-aged stand structure on the growth of these intolerant trees. This article reports a study of the relation of stand age structure to the height, diameter growth, and frequency of rot.

Study Area and Sampling Methods

The study area is in northwestern Colorado on the Bear Ears District of the Routt National Forest. The majority of the aspen occurs at elevations of 7,900 to 9,500 feet. The climate varies from somewhat arid at the lower elevations to subhumid temperate at the higher. Annual precipitation ranges from 30 to 50 inches and is mostly in the form of snow. The soils are a mixture of sands, silts, and volcanic fragments.

A total of 20 research plots was established in five separate stands scattered throughout the district. A stand was defined as a manageable, mappable area of homogeneous (pure) aspen at least 40 acres in size. The stands sampled averaged 150 acres and were previously were located on a transect and spaced 300 feet apart. About each plot center 25 trees were measured for d.b.h. (minimum size 2 inches), height, and age, and classed as dominant and codominant or suppressed (Smith 1962). Age cores were examined for the presence of rot. The cores were moistened with water and covered with soft graphite lead to highlight the rings, which were then counted under a binocular microscope to determine tree age. Site index for each stand was calculated from Jones's aspen site index curves (Jones 1967).

Statistical Procedures

The descriptive statistics of mean age, standard deviation, and sample age frequency distributions were calculated for each stand.

The effect of the uneven-aged structure on diameter and height growth was determined by linear regression. The regressions were derived from pooled data from all five stands. This procedure was deemed acceptable since site index was generally the same for the five stands, averaging 75 feet at 80 years. One pair of regressions compared diameters of dominant and codominant trees to diameters of suppressed trees. Another pair compared heights of dominant and codominant trees to those of suppressed trees. All regressions used

Table 1. Stand ages.

Stand	Mean	Standard deviation
	Years	*Years*
Entire population	84.0	30.7
Stand 1	73.0	28.2
Stand 2	75.7	44.2
Stand 3	93.4	18.7
Stand 4	91.7	35.0
Stand 5	70.5	16.0

relatively frequency of rot in the suppressed trees was calculated for each stand.

Stand Structure and Impacts on Growth

The mean ages of the entire population and stands are close to that considered average for the central Rocky Mountains, that is, approximately 80 to 100 years (Mathison 1976, Wengert 1976). The standard deviations for age (*table 1*) and the age and diameter frequency distributions (*tables 2* and *3*) illustrate the uneven-aged and varied diameter structure.

Some stands have a narrower age distribution than others, but none fit the definition of even aged, namely, a range of ages which does not exceed 20 percent of the rotation age (Smith 1962). With a rotation age of 80 for Rocky Mountain aspen (Mathison 1976, Hronek 1976), even aged would be defined as a 16-year range between the youngest and oldest trees. However, few of the stands depict the classical inverse J-shaped age and diameter distributions of uneven-aged, or what some might term all-aged, stands. Although stand 2 tends to resemble such distributions (*tables 2* and *3*), stands 3 and 4 (*table 3*) have diameter distributions similar to what might be expected in an even-aged stand. But stands 3 and 4 also have a wide range in tree ages.

Most of the stands include older trees, relics of past stands. The distributions exhibit the dynamic characteristics described by Jones (1973), the break-up of the older canopy creating openings that stimulate sprouting and the development of younger aspen trees. Stand 2 has two distinct broad-age populations, 31–100 and 111–151, whereas in stand 4 the regeneration cycle seems to have been more or less continuous (*table 2*).

This range and frequency of the age distribution is probably related to the rate at which the trees in the

Table 2. Number of sample trees by age class for the five stands categorized by dominant–codominant (D-C) and suppressed trees (S).

Stand	Tree class	Age class in years													
		11–30	31–40	41–50	51–60	61–70	71–80	81–90	91–100	101–110	111–120	121–130	131–140	141–150	151+
1 (3 plots)	D-C	1	3	4	9	13	4	5				1	7	1	
	S			4	4	9	2	5	1			2			
2 (3 plots)	D-C		5	20	13	4	3	2	2		2	1		11	2
	S			2	1		3							4	
3 (6 plots)	D-C				5	4	12	16	17	43	11			6	
	S		1	3	2	4	14	8	3	1					
4 (5 plots)	D-C	5	4	4	1	2	9	24	16	11	13	1	4	13	2
	S	1	2	1	3	3	3	2	1						
5 (3 plots)	D-C			6	4	1	26	20		1					
	S			10		5	2								

Table 3. Number of sample trees by diameter class for the five stands.

Stand	Diameter class in inches											
	2.1–4.0	4.1–6.0	6.1–8.0	8.1–10.0	10.1–12.0	12.1–14.0	14.1–16.0	16.1–18.0	18.1–20.0	20.1–22.0	22.1–24.0	24.1–26.0
1	12	21	17	10	2	5	4	3		1		
2	12	24	16	4	2	5	1	4	3	1	1	2
3	11	14	24	37	37	18	6	3				
4	19	14	18	25	23	19	3	4				
5	13	11	5	15	26	3	2					

will be created, depending on the rate and distribution of the overstory mortality. In essence, the stand becomes a mosaic of very small patches. Individual trees within these patches will often be suppressed, again depending on the rate of overstory mortality and the corresponding stocking of the overstory. The stand structures in this study seem to have been created by a gradual dying of the overstory, as the small individual sample plots also exhibit a wide range in d.b.h. and tree age.

A certain number of the trees of various ages, mostly in the 20- to 90-year range, have become suppressed under the conditions described above. The extent of this suppression varies somewhat with overstory stocking. For example, the heavily stocked overstory of stand 3 has created a greater proportion of suppressed trees than the more lightly stocked stand 2 (*table 2*).

The regressions indicate the influence of the uneven-aged structure (and its inherent storied effect on the stand) on diameter and height growth. For both of these measures, the slope of the dominant and codominant equation differed significantly from that of the suppressed. When compared to dominant and codominant trees, the diameters of suppressed trees range from 22 to 24 percent less and the heights from 25 to 28 percent less (*figs. 1* and *2*). This relative difference remains fairly constant over a wide range of tree ages. In absolute terms, the effect of suppression increases with tree age. For example, at age 40 the difference in d.b.h. is 1.23 inches and the difference in height is 10 feet between the suppressed and dominant and codominant trees, whereas at age 100 the difference is 2.8 inches and 23 feet.

In all the stands examined, the percentage of trees rotten is always greater in the suppressed trees (*table 4*). In stands 2 and 4, for example, the percentage rotten was more than double that of the dominant and codominant trees. That more rot occurs in the understory is consistent with findings on some other tree species, and probably would occur regardless of whether the overstory was even or uneven aged (USDA Forest Service 1965).

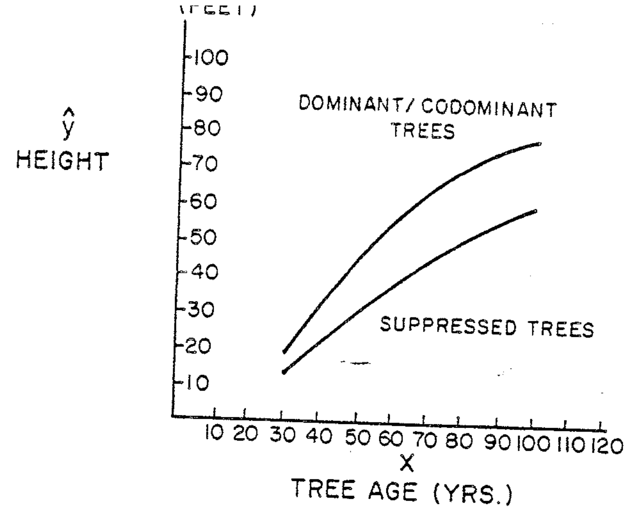

Figure 1. Relationships of height to age of dominant–codominant and suppressed trees.

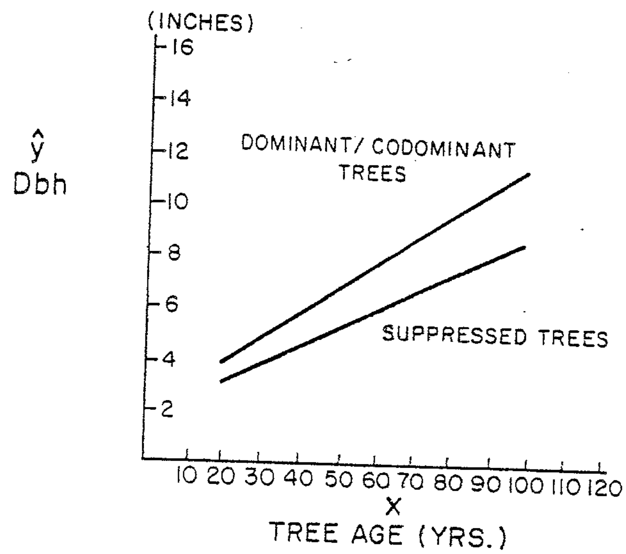

Figure 2. Relationships of d.b.h. to age of dominant–codominant and suppressed trees.

Implications

Compared to overstory trees of the same age, aspens in the understory of these uneven-aged stands have significantly less height and diameter and markedly higher frequency of rot. The high frequency of rot indicates that some of these suppressed trees may not respond vigorously after the natural death of the overstory. The loss in volume and wood quality in such stands would probably be quite large if known for the entire Rocky Mountain region. Growth and quality would be significantly greater if the stands were even aged. In the opinion of the authors, the uneven-aged structure is likely to continue, to a certain degree, in the stands studied here and in many others in the Rocky Mountains unless stands are destroyed by a major disturbance (e.g., fire or clearcutting) or convert to conifers.

From an economic standpoint, the loss cannot now be considered important, for very few wood products markets exist for Rocky Mountain aspen. Many speakers at a recent symposium (USDA Forest Service 1976) indicated markets may improve in the future. But the current harvest is very small, and most of the aspen acreage is classed by the USDA Forest Service as either in the "marginal" or the "unregulated" component. Wood products presently consist mostly of pallet and paneling material and specialty items such as matchsticks or excelsior. A number of reasons account for this lack of utilization, but certainly the quality of the raw material is one key factor (Wengert 1976). If markets improve, aspen probably can be managed to improve its timber quality.

The total ...

Table 4. Relative frequency (percent) of rotten trees in dominant and codominant and suppressed categories.

Stand	Dominant and codominant	Suppressed
1	57.1	85.0
2	14.5	100.0
3	21.9	36.1
4	12.0	47.1
5	44.8	87.5

aged situation are difficult to assess. Despite the negative effects on timber growth and quality, the uneven-aged structure may create benefits for wildlife habitat or enhance production of forage for domestic livestock. Management of Rocky Mountain aspen would need to include all uses. ◼

Literature Cited

BAKER, F. S. 1925. Aspen in the central Rocky Mountain region. USDA Agric. Bull. 1291, 46 p.

BARRETT, J. W. 1962. Regional Silviculture of the United States. Ronald Press Company, New York. 610 p.

FETHEROLF, J. M. 1917. Aspen as a permanent forest type. J. For. 15:757–760.

HINDS, T. E., and E. M. WENGERT. 1977. Growth and decay losses in Colorado aspen. USDA For. Serv. Res. Pap. RM-193, 10 p.

HRONEK, B. B. 1976. Aspen potential—a land manager's viewpoint. P. 12–14 *in* Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains. USDA For. Serv. Gen. Tech. Rep. RM-29.

JONES, J. R. 1967. Aspen site index in the Rocky Mountains. J. For. 68:820–821.

JONES, J. R. 1973. Rocky Mountain aspen. P. 49–51 *in* Silvicultural Systems for Major Forest Types of the United States. USDA Agric. Handb. 445.

MATHISON, R. S. 1976. Aspen in perspective in Colorado. P. 8–9 *in* Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains. USDA For. Serv. Gen. Tech. Rep. RM-29.

MUEGGLER, W.F. 1976. Type variability and succession in Rocky Mountain aspen. P. 16–19 *in* Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains. USDA For. Serv. Gen. Tech. Rep. RM-29.

SMITH, D. M. 1962. The Practice of Silviculture. John Wiley and Sons, Inc., New York. 578 p.

USDA FOREST SERVICE. 1965. Silvics of Forest Trees of the United States. Agric. Handb. 271. 762 p.

USDA FOREST SERVICE. 1976. Proceedings: Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains. USDA For. Serv. Gen. Tech. Rep. RM-29, 120 p.

WENGERT, E. M. 1976. Perspectives on Rocky Mountain aspen resource: an overview. P. 2–5 *in* Utilization and Marketing as Tools for Aspen Management in the Rocky Mountains. USDA For. Serv. Gen. Tech. Rep. RM-29.

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