
PLOTS THINNED TO 1000 TREES/HA

As in unthinned plots with Armillaria root rot, stand density declined more rapidly with stand age (Fig.16) and average dbh increased more rapidly (Fig..17) than in the healthy plot. Densities were negligibly different between the two levels of disease incidence but average dbh was higher in the 43% plot.

Average tree volume increased most rapidly in the plot with 43% (heavy) incidence of Armillaria root rot and least rapidly in the healthy plot. The plot with 19% Armillaria root rot incidence was only slightly less than in the 43% plot (Fig.16).

Volume/ha increased most rapidly in the plot with 43% Armillaria root rot and initially least rapidly in the healthy plot, but equalling that of 19% Armillaria root rot plot at stand age 120 (Fig.19). The difference between the healthy and the Armillaria plots was about 100 cu. in/ha.

FIGURE 15

Effect of Armillaria on Volume/Ha in Unthinned Coastal Douglas-Fir

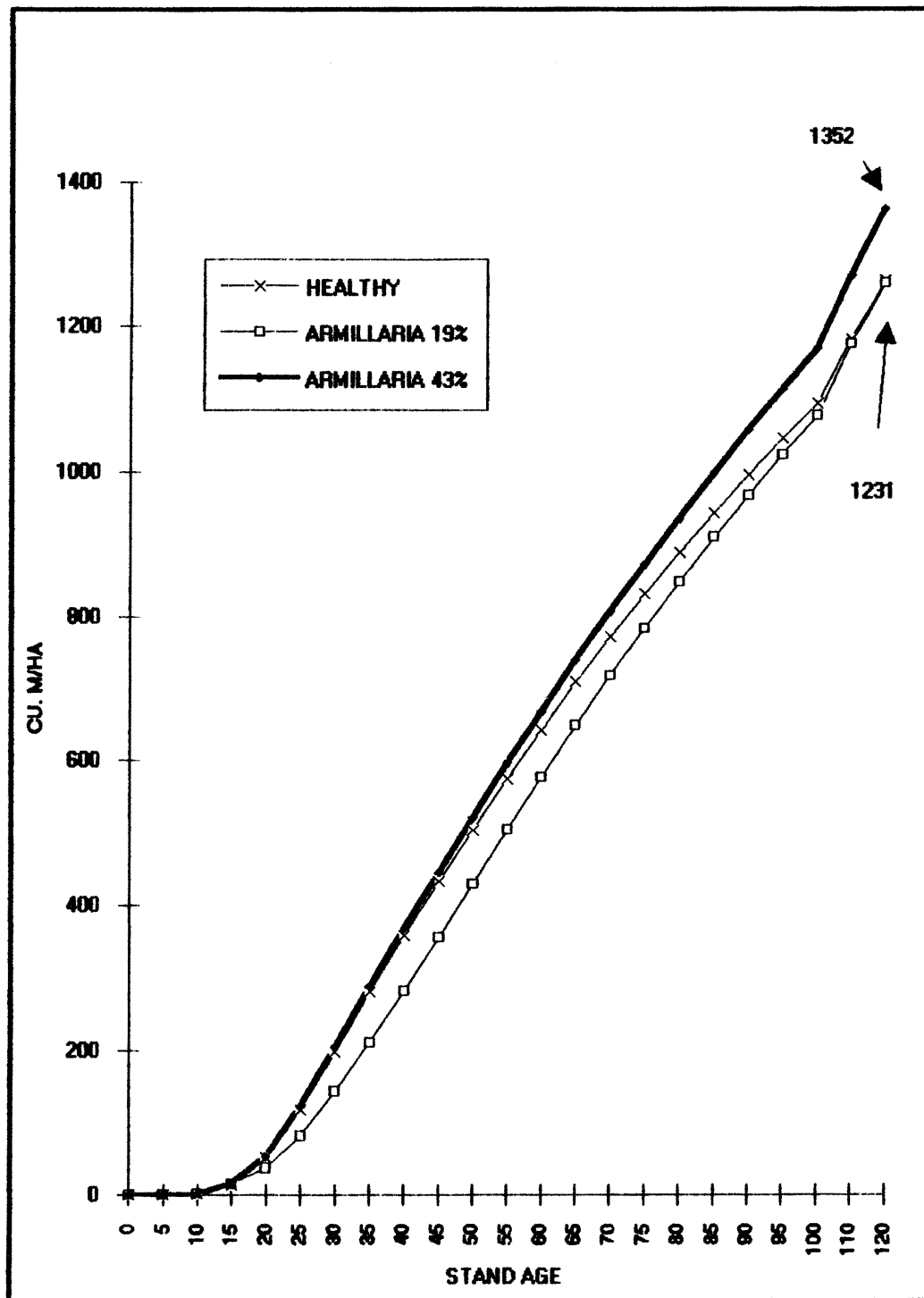


FIGURE 14

Effect of Armillaria on Average Volume in Unthinned Coastal Douglas-Fir

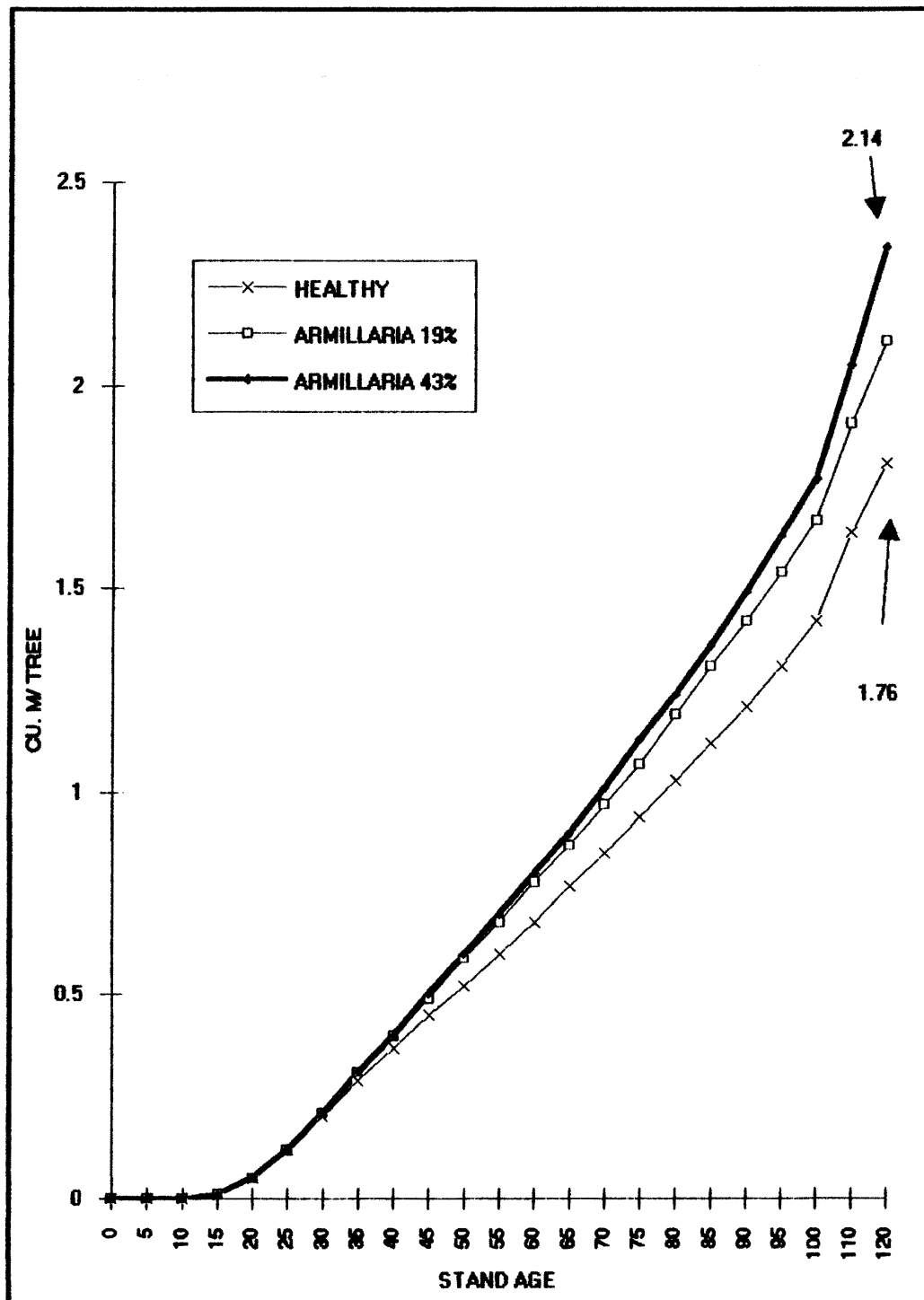


FIGURE 13

Effect of Armillaria on Average DBH in Unthinned Coastal Douglas-Fir

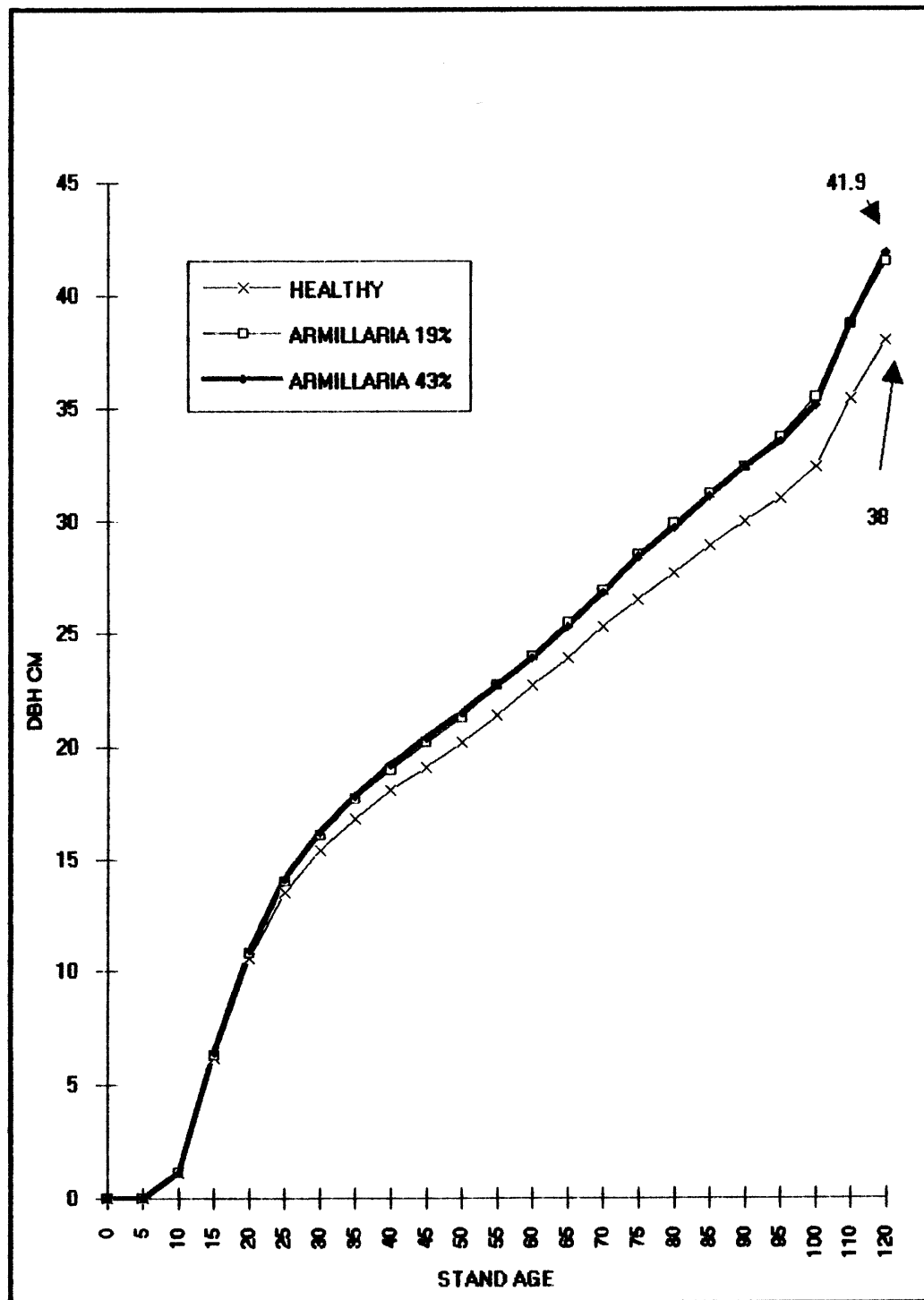
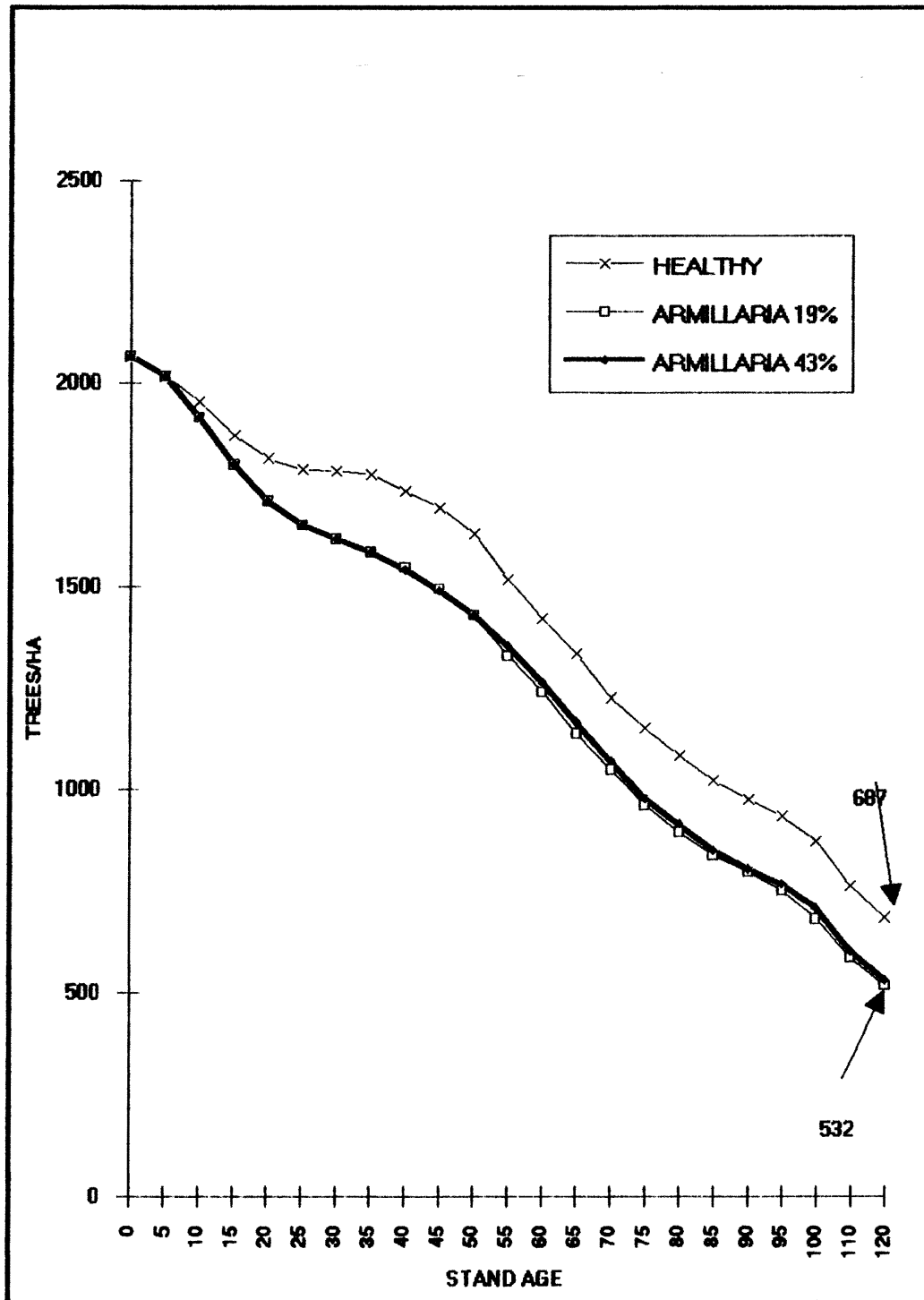


FIGURE 12

Effect of Armillaria on Stand Density in Unthinned Coastal Douglas-Fir



Simulations were run with and without Armillaria mortality and with and without thinning (juvenile spacing) at stand age 15 to final densities of 1000 or 500 trees/ha. Tree growth (average volume, average dbh) and stand growth (trees/ha and volume/ha) were tabulated and plotted at 5-yr stand ages to age 120. Armillaria root rot mortality was not included beyond age 50, because plot data did not extend beyond then. Therefore, the effects of the disease are likely underestimated though diminishing with time.

RESULTS

UNTHINNED PLOTS

In unthinned plots with Armillaria root rot, stand density declined more rapidly with stand age (Fig.12) and average dbh increased more rapidly (Fig.13) than in the healthy plot. Densities were negligibly different between the two levels of disease incidence.

Average tree volume increased most rapidly in the plot with 43% (heavy) incidence of Armillaria root rot and least rapidly in the healthy plot. The plot with 19% Armillaria root rot incidence was intermediate (Fig.14).

Volume/ha increased most rapidly in the plot with 43% Armillaria root rot and initially least rapidly in the healthy plot, but equalling that of 19% Armillaria root rot plot at stand age 120 (Fig.15). The difference between the healthy and the Armillaria plots was about 120 cu. in/ha.

T A B L E 3 .

Distribution of Armillaria Root Rot in Tsable R. Plot

STAND AGE	NO. CLASSES	DISTRIBUTION	NO. TREES/HA/5-CM DBH CLASS					TOTAL
			0-5	5-10	10-15	15-20	20-25	
5	3	CONCENTR SCATTERED	11 2	19 3	8 1			38 6
10	3	CONCENTR SCATTERED	46 7	69 11	3	1	1	120 18
15	7	CONCENTR SCATTERED	18 3	40 7	4 1	2		64 11
20	7	CONCENTR. SCATTERED	15 2	6 1	4 1	2		27 4
25	10	CONCENTR. SCATTERED	3	2	1			6
30	10	CONCENTR. SCATTERED	8 1	8 1	2	2	1	21 2
35	9	CONCENTR. SCATTERED	8 1	3	2	2		15 1
40	10	CONCENTR. SCATTERED	2	3	2	1		8
TOTAL								297

Concentrations were defined in TASS inputs as a single circular area central within a 1 ha (100m x 100m) plot. In the case of Campbell R. the area was equal to the sum of individual concentrations. Because of the random distribution of killed trees both inside and outside concentrations, no effect on tree growth was likely by lumping concentrations into one, nor was the shape of the area of any consequence.

Mortality was allocated by TASS inside and outside concentrations in accordance with the no./ha. dbh class, and stand age. In a control run, no Armillaria mortality was included.

T A B L E 2 .

Distribution of Armillaria Root Rot in Campbell R. Plot

STAND	NO.	DISTRIBUTION	NO. TREES/HA/5-CM DBH CLASS				
AGE	CLASSES		0-5	5-10	10-15	15-20	TOTAL
5	3	CONCENTR	3	8	3		14
		SCATTERED	1	3	1		5
10	3	CONCENTR	13	13			26
		SCATTERED	5	5			10
15	3	CONCENTR	20	14			34
		SCATTERED	7	5			12
20	5	CONCENTR.	4	7	2		13
		SCATTERED	2	3	1		6
25	6	CONCENTR.	8	9	4		21
		SCATTERED	3	3	1		7
30	7	CONCENTR.	6	19	7	1	33
		SCATTERED	2	7	3		12
35	8	CONCENTR.	2	11	5	1	19
		SCATTERED	1	4	2		7
40	9	CONCENTR.	1	12	10	1	24
		SCATTERED		5	4		9
45	9	CONCENTR.		6	12	2	20
		SCATTERED		2	4	1	7
TOTAL							260

SIMULATION OF ARMILLARIA ROOT ROT

METHODS

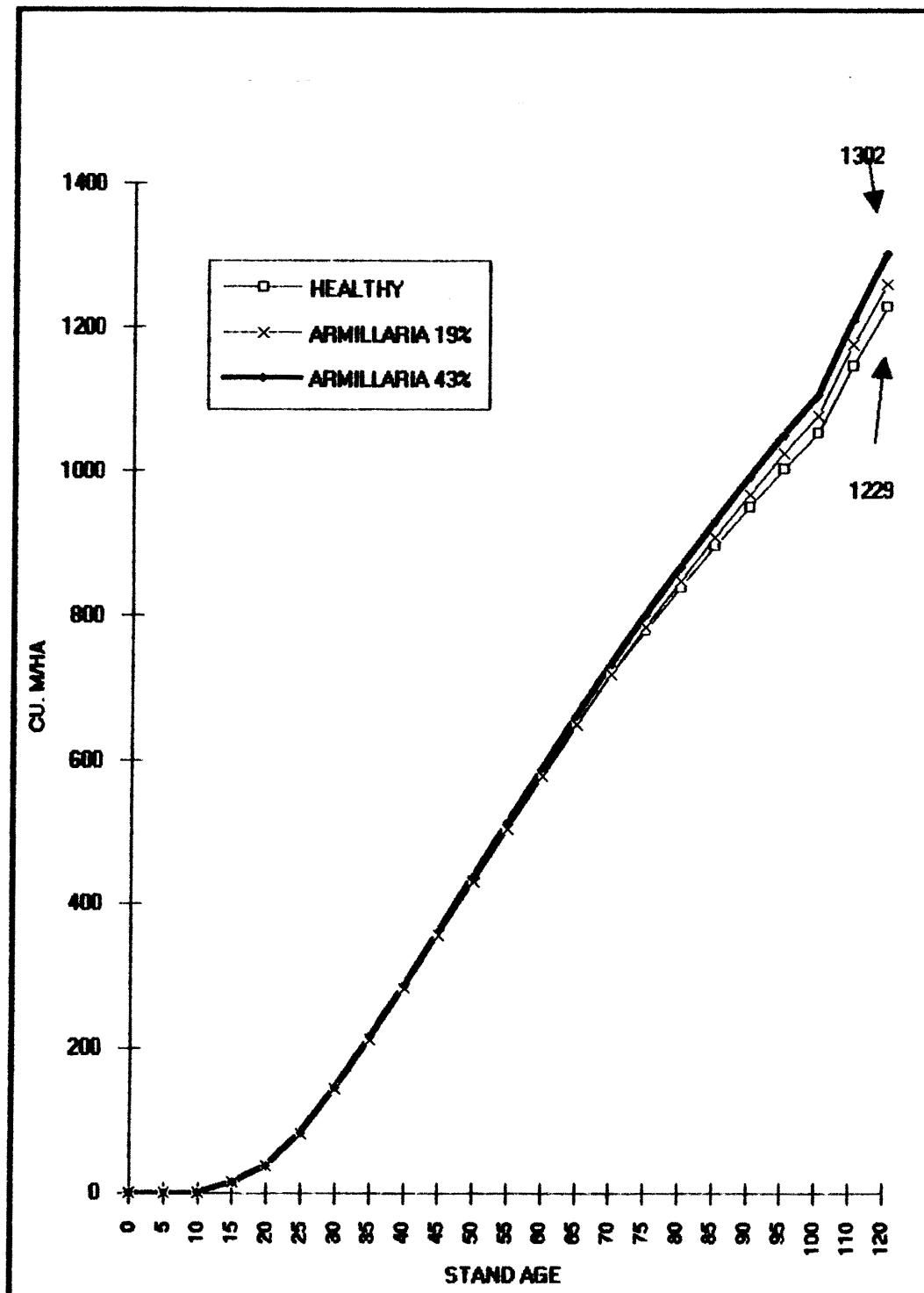
From the above plots, number of trees/ha killed by Armillaria root rot by 5-cm dbh classes and by 5-yr stand ages were included as mortality inputs to the Tree and Stand Simulator (TASS) (K. Poison, personal communication). Spatial distribution was based on that found in the plots which were assumed to be representative of 45-50 yr-old plantations. Stand parameter inputs were: initial tree spacing 2mx2m (approximately 2070 trees/ha). pure Douglas fir, site index 30m at 50 yr.

Campbell R. and Tsable R. Block 1. having total Armillaria root rot concentrations of 1950 and 4385 sq. in/ha (19.5 and 43.8%) respectively. were selected as representative of moderate and heavy incidence.

Numbers of trees/ha with Armillaria root rot occurring in concentrations or scattered at 5-yr age classes and in 5-cm dbh classes were derived from plot data (Tables 2-3).

FIGURE 23

Effect of Armillaria on Volume/Ha in Coastal Douglas-Fir Thinned to 500 sph



DISCUSSION

Armillaria appears to behave as a natural thinning agent as evidenced by the larger average dbh and tree volumes in infected plots. Increased average tree growth was probably due to the removal of smaller trees, rather than to thinning per se, since the effect was pronounced even in the thinned plots. However, increases in tree volume in Armillaria plots were offset by the reduction in stand density so that volume/ha was only slightly higher than in the healthy plots. Generally, the greatest gains in tree growth were in the plot with heavier incidence of Armillaria (43%).

Although permanent plot data only extended to 50 yr., it is unlikely that the trends apparent from simulation would be reversed as stands became older. In fact, the continued removal by Armillaria of suppressed trees may even increase its effect on growth of the remaining trees.

IMPLICATIONS FOR FOREST MANAGEMENT

According to the simulation results, presence of Armillaria in a stand should not prejudice thinning operations, except perhaps where the incidence is heavy and the thinning results in a sparse stand. In that case, continued killing by Armillaria may reduce stocking below desirable levels, even though average tree growth increases. Inclusion of Armillaria mortality in TASS would add further reality to mortality in general.

REFERENCES

- Beale, J.D. 1987. A survey of the incidence and severity of root diseases and their management in the Vancouver Forest Region. B.C. Min. For. Rept. PM—V-10.
- Foster, R.E. & A.L.S. Johnson. 1963. Assessments of pattern, frequency distribution, and sampling of forest disease in Douglas fir plantations. Pac. Cen., For. Can. For. Publ. 1011.
- Morrison, D.J. 1981. Armillaria root disease. Pac. For. Cen., For. Can. BCX 203.