

**IMPACT OF DWARF MISTLETOE
ON GROWTH IN LODGEPOLE PINE TREES**

by

J. Pousette, R.P.F.
Industrial Forestry Service Ltd.
1595 5th Avenue
Prince George, British Columbia

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FOREWORD

This report is one of a series of internal reports distributed by Forest Protection Branch, B.C. Ministry of Forests, to record accomplishments and interim or provisional results for the information of staff, colleagues, and others.

In the Canada-British Columbia Forest Resources Development Agreement (FRDA) 1985 to 1990, over 100 pest control projects were directly funded by the province and administered by protection staff. To facilitate application of the results, and development of improved forest health management strategies, the contractors reports have been edited and distributed as internal reports. Accordingly, any opinions and recommendations expressed are those of the contractor, and not necessarily those of the ministry or the FRDA management committee.

For details or more information about the report or project, please contact forest health staff at Protection Branch or at the forest region offices.

J. Muir, RPF
Acting Manager
Forest Health
Forest Protection Branch

The guidelines for internal reports outlined in the Protection Manual were adhered to as closely as possible. All manuscripts were altered to comply with a common format, but entire reports were not rewritten to conform to a standardized outline.

Most Executive Summaries were the work of Graham Hawkins of MoF Inventory Branch (formerly with Pacific Coast Forest Biology). All word processing was accomplished by Catriona Kaufman of Top Kat Services. Will Gordon of R. White Woods inc. prepared all maps and figures.

R. White, editor
R. White Woods inc.

EXECUTIVE SUMMARY

The objectives of the project were to:

1. determine if a correction factor based on pine dwarf mistletoe (PDM) is required for whole stem volume equivalents.
2. select a single stand suitable for stem sampling based on survey data from Forest Health Project PB-2.
3. establish plots to determine dbh and stocking and select 25 dominant and co-dominant sample trees in each plot. Rate each tree for lodgepole pine (Pl) dwarf mistletoe, fell trees, measure total tree height, and cut discs (sample points) for radial measurements.
4. analyze radial measurements to obtain stem profiles for each infection class and compare volumes for each infection class.

This study was initiated to resolve the question of whether or not Pl dwarf mistletoe-infected trees have less taper than healthy trees. If dwarf mistletoe caused a decrease in height with respect to dbh, then standard taper volumes could not be used for comparing dwarf mistletoe-infected ratings unless a correction factor was derived. It was felt that this problem may have affected earlier results (PB-2a plot analysis). Thus, samples were taken and analyzed to determine if tree shape was altered by dwarf mistletoe and to derive suitable correction factors for the standard whole stem volume equivalents used by the MoF. A single age class stand, consisting of 60-80 year old lodgepole pine on a medium site within the SBSk2 biogeoclimatic subzone variant, was considered to be the best representation of lodgepole pine stands in the area. Twenty-five trees were felled in each selected plot, representing Healthy (DMR 0, 1 and 2), Moderate (DMR 3 and 4), Severe (DMR 5 and 6) and Control (no dwarf mistletoe). After felling 100 suitable trees, discs (sample points) were cut and two radii/disc were measured. Total tree height was also measured. Five-year radial increment was averaged and recorded for each disc.

Data were analyzed on a VAX computer to construct complete stem profiles of each tree. Average stem profiles were then determined for each infection class. Total (gross) volume for each year from age 20 to total age was calculated using the Smalian formula. These measured volumes/infection rating were then compared to the expected whole stem volume equivalents in order to derive volume correction factors. There was very little difference between the observed (Smalian) volumes and the expected (whole stem volume equivalents) volumes, thus indicating that dwarf mistletoe had a very negligible impact on (taper) tree shape at any infection level. However, the impact of infection on volume at specific ages was not considered. In addition, variations in stand density were not accounted for.

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INTRODUCTION

The objective of this study is to quantify the volume loss attributable to dwarf mistletoe (*Arceuthobium americanum* Nutt. ex Engelman) infection in lodgepole pine. Previous studies by Thomson *et al.* (1984, 1985) have focused on the volume losses associated with *Arceuthobium tsugense* (Rosendahl) G.N. Jones in young western hemlock stands. In these studies, finding adequate healthy controls was a concern. Controls were often samples from different parts of the stand from where infected trees were sampled. In this study, a homogeneous lodgepole pine stand containing sufficient numbers of both infected and healthy trees was studied. Differences in volume growth attributable to variations in site, nutrient regime, moisture and competition were minimal. No correction for differences in history of suppression or age was necessary.

This study quantifies the volume loss associated with dwarf mistletoe infection in lodgepole pine, and thus provides a basis for policy decisions regarding control of this pest.

2 METHODS

The data was collected in central British Columbia from a 3.5ha area of a pure lodgepole pine stand (approximately 60km south of Prince George). The stand was selected using information from B.C. MoF forest inventory maps and roadside survey data collected in FRDA Pest Control Project PB-2. Since previous authors have expressed concern in obtaining adequate healthy controls (Thomson *et al.* 1984, 1985), considerable time was spent ensuring that the stand selected had sufficient samples of all degrees of infection, and that this stand was uniform in all respects.

The stand selected was within the SBSk2 ecosystem unit. The nutrient regime was submesotrophic to mesotrophic, and the moisture regime submesic to mesic. The association was 01/06. Average slope was two percent. Several fixed area plots were established, and from information collected the average stem diameter was 13.6cm. The stocking was determined to be 2 250 stems/ha.

The original experimental design called for three infection classes to be the basis for this study. These classes were: healthy (H), moderate (M), and severe (S), and were groupings of the Hawksworth (1977) six-point system. The healthy class was to include all trees with a dwarf mistletoe rating (DMR) of 0, 1 and 2. The moderate and severe classes were to include trees with rating 3 or 4, and 5 or 6, respectively. This class system was the same as Thomson (1985) used in studying dwarf mistletoe in western hemlock. In the process of this analysis, these classes did not prove to be statistically sound groupings, and alternate classes were established. The classes used in this study included Healthy (H) and infected (I). The healthy class included Hawksworth's (1977) 0 and 1 rated trees, and the infected included all trees with ratings of 2, 3, 4, 5 and 6.

A minimum of 25 trees in each of the three initial infection classes were sampled. Sample selection was made from only dominant and co-dominant trees. This was done to ensure that trees sampled were not subject to extreme levels of competition during growth. Prior to felling, each tree was rated for mistletoe infection and cored to determine its age. If the tree was between 65 and 85 years of age, it was felled and immediately rated once more for infection. Both ratings were recorded. Total tree height was then measured and a 2-4cm thick disc (cross-section of the bole) was cut at stump (0.3m) and breast height (1.3m) and at 2.0m intervals up the tree. The discs were labelled and stored in sealed plastic bags for measurement upon completion of all sampling. If potential sample points (discs) lay within a bole swelling caused by mistletoe, discs were cut from the closest part of the bole where swelling was not evident. On all discs, five-year radial growth measurements were made, starting at the outside and working towards the centre of the disc. To reduce variability, these measurements were taken from two average radii.

Data collected were then analyzed with the aid of a VAX 11/780 computer. The two radii measurements were averaged and plots of height (m) versus five-year radial growth increment (cm) were done for all sample trees. Where necessary, the five-year height increment was calculated by dividing the distance between sample discs by the difference in the ages of the discs.

Volume at each five-year interval was calculated using the standard Smalian's formula. Annual volume increment was estimated as one-fifth the volume increase between successive five-year internodes (ages). Gross average annual tree volume (m^3) versus age was plotted for all seven of the Hawksworth (1977) dwarf mistletoe ratings (0-6). A visual inspection of these plots revealed that the peak annual volume increment did not seem to have been attained in most, if not all, of these volume curves (see Figure 1). For this reason, the Thomson *et al.* (1985) method of analysis, where volumes are compared at the youngest age, was chosen rather than the method which utilized the derivative of the logistic equation (Thomson *et al.* 1984).

Average volume at a comparison age of 60 years was calculated for all seven of the Hawksworth (1977) dwarf mistletoe ratings. A new Duncan's multiple range test was performed on these means, at a 0.05 level of confidence. Table 1 shows the results of this analysis.

On the basis of this analysis, the data were grouped into two classes. As was stated previously, the first class, labelled healthy (H), included all trees with a Hawksworth (1977) rating of 0 and 1. The second class, labelled infected (I), included all trees with a Hawksworth (1977) rating of 2, 3, 4, 5 and 6.

For both classes an average stem growth profile (Figures 3 and 4), a gross average annual tree volume profile (Figure 2), and a height growth pattern profile (Figure 5) were made. All of these profiles were generated using computer programs.

Average volume at a comparison age of 60 years was calculated for both the healthy and infected classes. Results of this comparison appear in Table 2.

3 RESULTS

Infected trees had an average of 30% less volume than healthy trees at a comparison age of 60 years. Figure 2 indicates that this difference is present at all ages above 30 years. Volume losses attributable to mortality are not included in this analysis.

Patterns of early growth are virtually identical for both the healthy and infected classes. This fact is seen clearly in Figures 3 and 4. This observation rules out the likelihood that differences in site or competition are reflected in the volume differences between classes. The stand was sufficiently homogeneous with respect to age and early growth history to conclude that healthy trees from the same area provided a good basis for comparison.

Height growth patterns (Figure 5) show fairly rapid initial height growth in both infection classes. The healthy class has slightly higher growth rates than the defective class. This factor also contributes to increased volume growth.

4 DISCUSSION

In this pilot study, no statistical evidence was found that would indicate that the three infection classes of Thomson *et al.* (1984) used in hemlock stands should be applied to lodgepole pine stands. Duncan's multiple range test of the average gross tree volume at age 60 for the initially proposed infection classes of healthy (H), moderate (M) and severe (S) showed no difference between the M and S classes. It was on the basis of this information the data were regrouped into the healthy (H) and infected (I) classes. Statistical tests showed these to be valid groupings.

The problem of healthy trees being adequate controls, as discussed by Thomson *et al.* (1984, 1985), was not evident in this study. Lodgepole pine stands tend to be homogeneous with respect to age, suppression and early growth characteristics, and are thus an ideal species for study.

Loss figures reported here are not truly comparable to those of Thomson *et al.* (1984, 1985). Infected trees had 30% less volume than healthy trees. Thomson *et al.* (1985) reported volume losses of 16-34% for the healthy to moderate trees, and 30-45% for the healthy to severe classes.

The Hawksworth (1977) six-point dwarf mistletoe rating (DMR) system provided a quick and easy estimate of crown infection. Examination of the difference between the standing estimated DMR and the actual rating given after felling showed that (although the ratings may have changed slightly) samples rarely moved from the healthy to infected class, or vice versa.

Considerable time was spent finding a stand where both infected and healthy trees co-existed. As was reported for hemlock species by Thomson *et al.* (1985), pine stands also tend to be either infected or healthy. The sample stands forest cover inventory label from the British Columbia Forest Service inventory maps was PL 420-M + PIF Vets. This suggested that the primary forest cover is lodgepole pine aged 60-80 years on a medium site. The average gross volume/tree at age 60, 0.10m³, the number of stems/ha, 2 250, and the SBSk2 01/06 ecological association suggest that the site was poor rather than medium.

Impacts of dwarf mistletoe infection on individual tree volume has been examined in this study. Volume losses on a per stand or per hectare basis would depend, as Thomson *et al.* (1984) reported, on the proportion of the stand which was infected. The validity of stand sanitation projects as control of dwarf mistletoe infections is validated by both the young age at which volume losses are evident and the fact that mistletoe rapidly spreads to all trees in a particular stand.

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TABLE 1 AVERAGE GROSS TREE VOLUME AND NUMBER OF SAMPLES BY HAWKSWORTH'S (1977) DWARF MISTLETOE RATING (DMR).

(The results of Duncan's Multiple Range Test are shown by the horizontal lines.)

DMR	5	2	4	3	6	0	1
Number of trees	10	5	14	13	22	10	8
Average volume at Age 60 (m3)	0.0711	0.0839	0.0959	0.0966	0.1011	0.1287	0.145
Summary of results of Duncan's multiple range test (0.05 level of significance)							

TABLE 2 THE NUMBER OF TREES, AVERAGE AGE, VOLUME AT AGE 60, AND PERCENT LOSS RELATED TO THE INFECTED (I) VERSUS HEALTHY (H) CLASSES

Class	No. of Trees	Average Age (years)	Volume at age 60 years ¹ (m3)	% Loss ²
H	18	72	0.1357 ± 0.0236	
I	61	74	0.0943 ± 0.0073	30.5

¹ Mean ± Error of estimate at the 95% level of confidence

² Percent loss = $((\text{Volume}_H - \text{Volume}_I) / \text{Volume}_H) \times 100$

FIGURE 1 **AVERAGE GROSS TREE VOLUME-AGE CURVES FOR**
HAWKSWORTH'S (1977) DMR CLASSES
 (The age at which volumes are compared is
 shown by the vertical dashed line.)

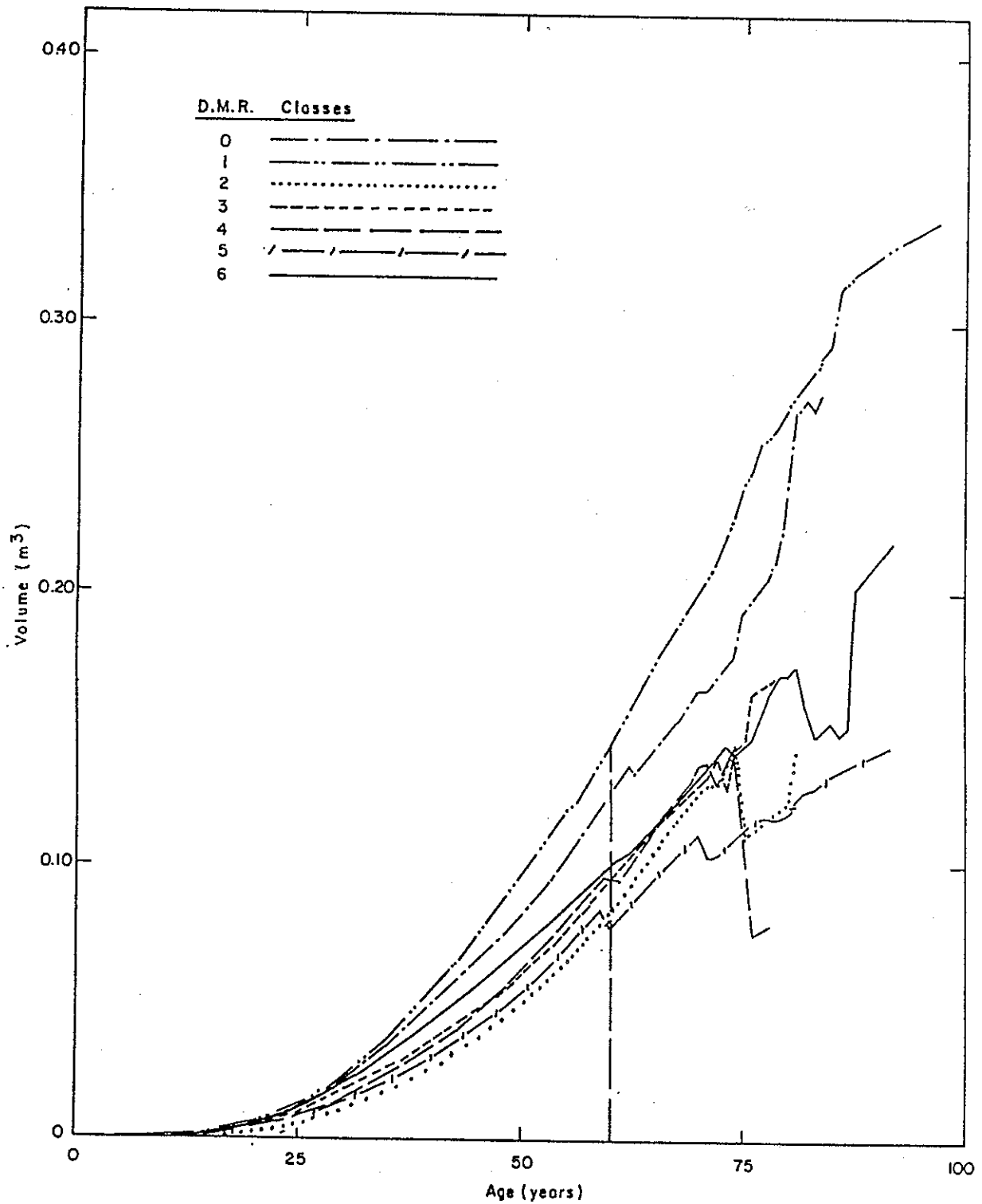


FIGURE 2 **AVERAGE GROSS TREE VOLUME-AGE CURVES FOR**
HEALTHY AND INFECTED CLASSES
(The age at which volumes are compared is
shown by the vertical dashed line.)

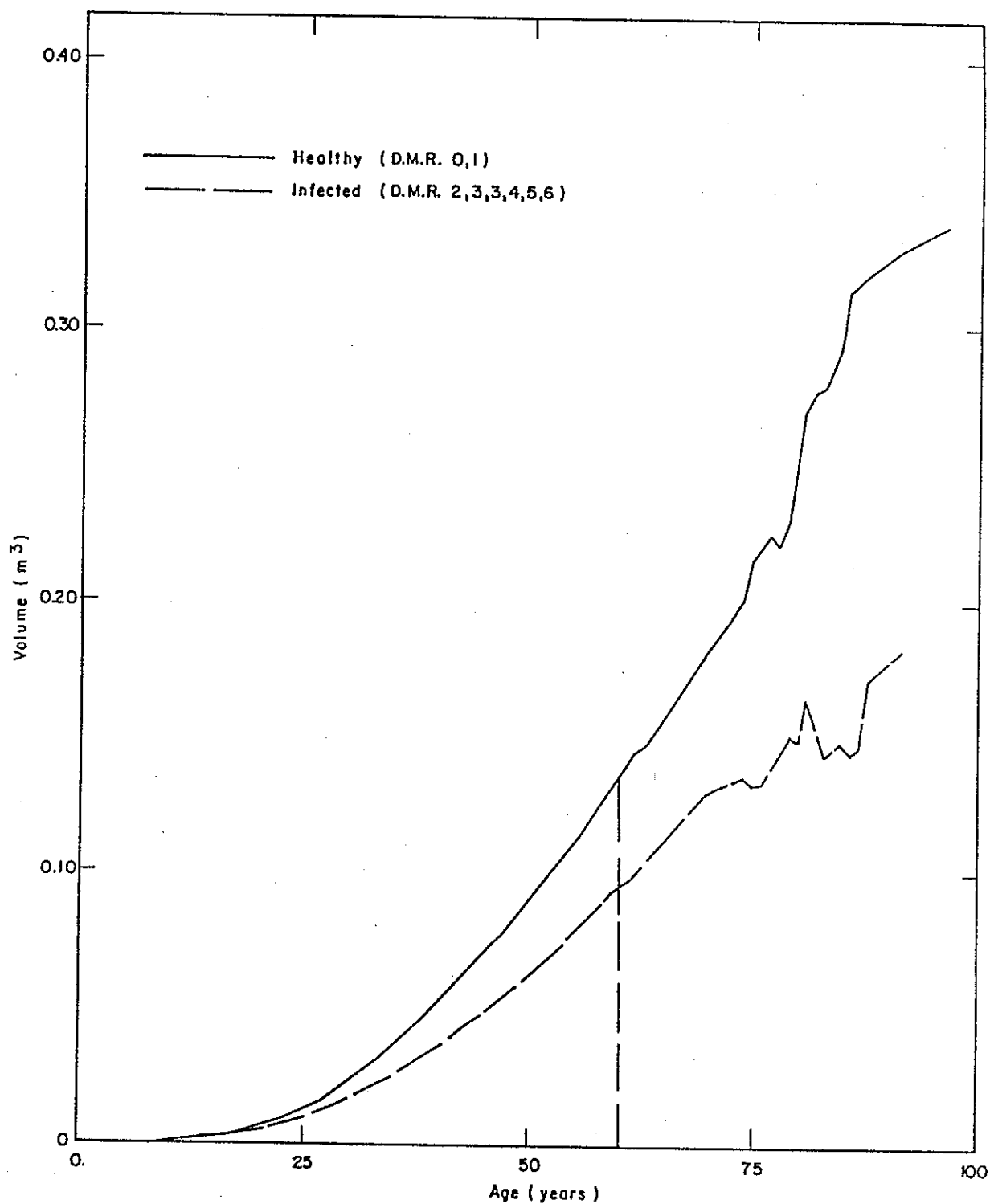


FIGURE 3 AVERAGE GROWTH PROFILE OF HEALTHY TREES

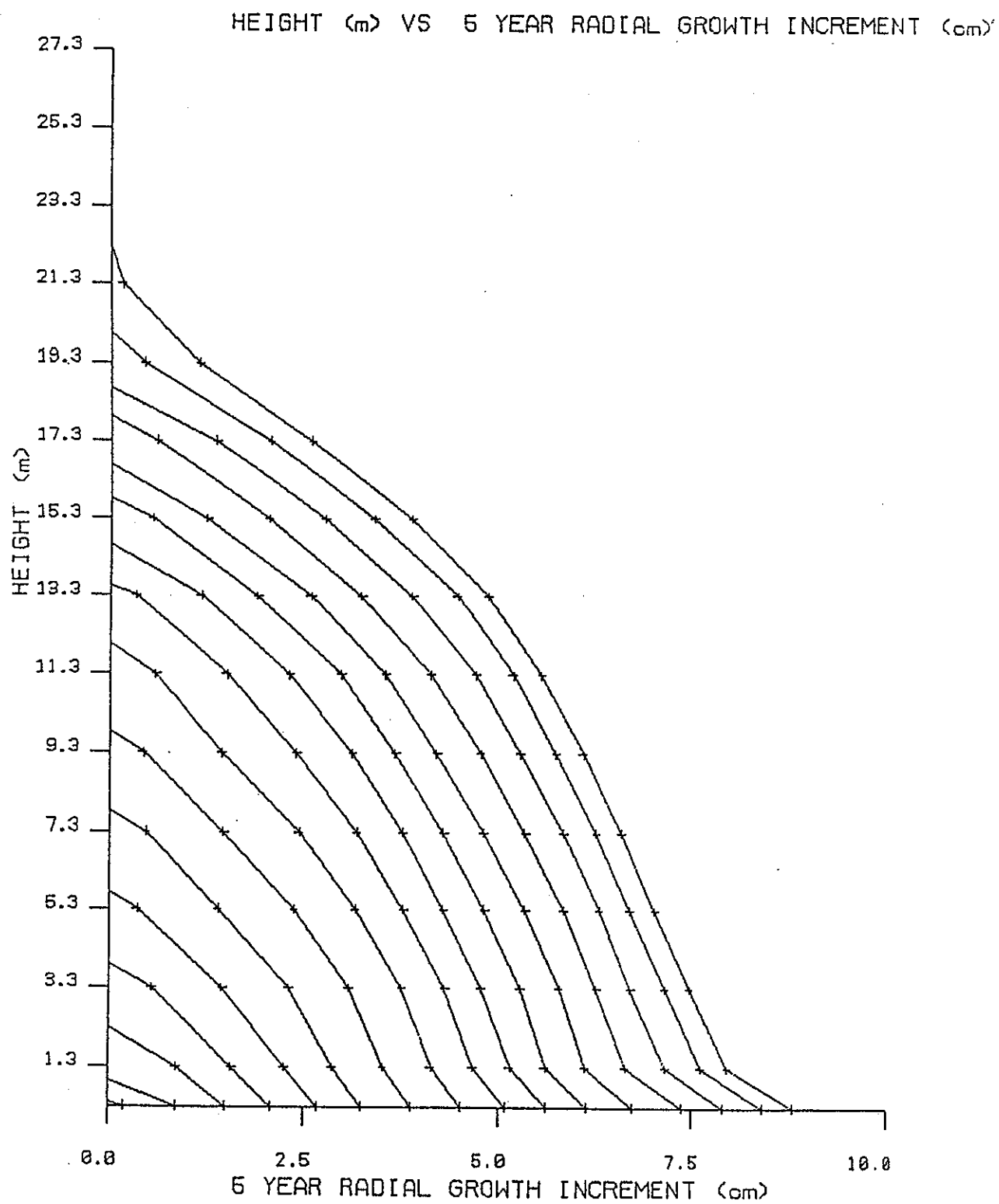


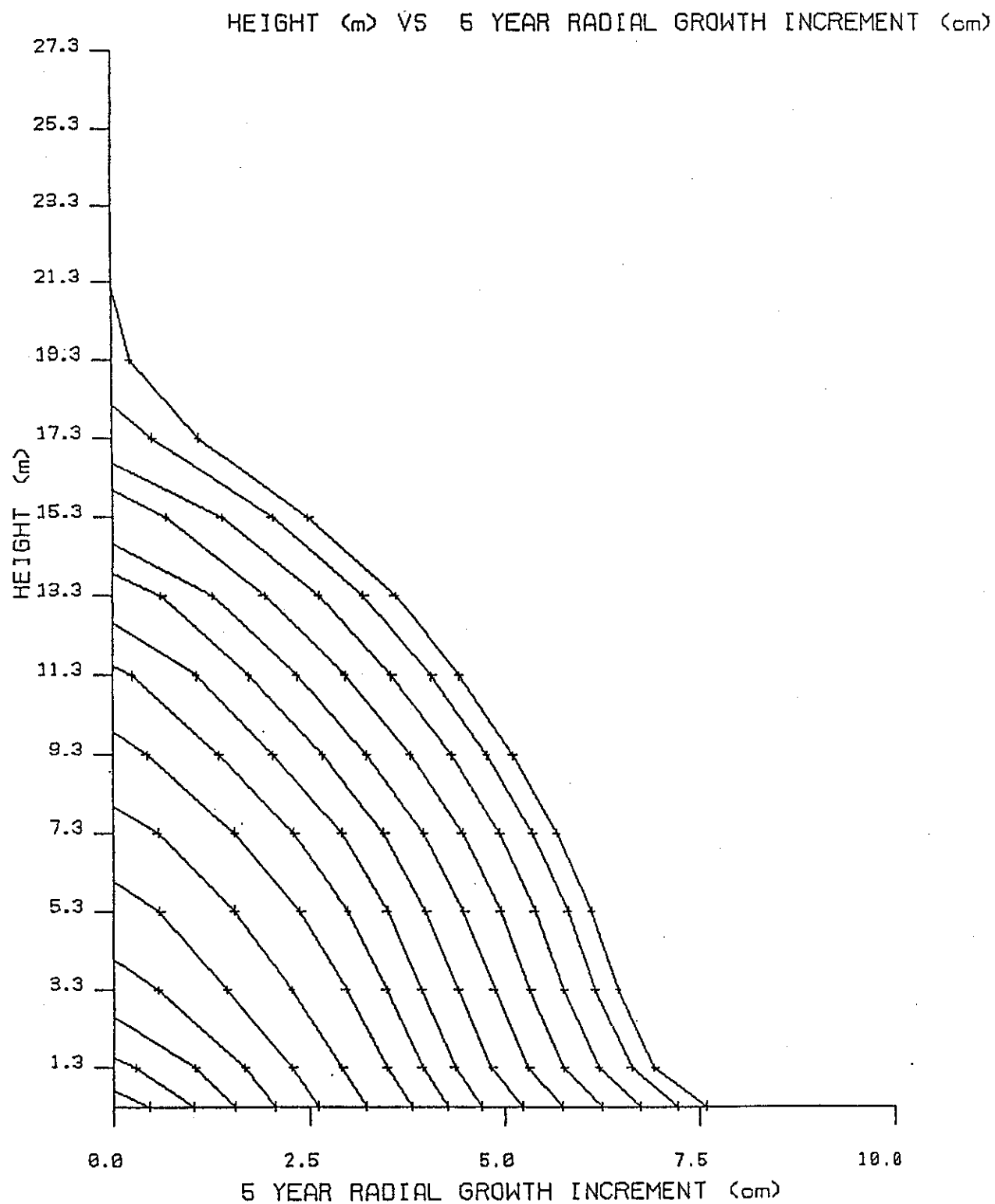
FIGURE 4 AVERAGE GROWTH PROFILE OF INFECTED TREES

FIGURE 5 **HEIGHT GROWTH PATTERNS OF HEALTHY AND
INFECTED SAMPLE TREES**

