A TEST OF THE STAND PROJECTION TECHNIQUE, RMYLD, FOR DWARF MISTLETOE-INFECTED LODGEPOLE PINE IN BRITISH COLUMBIA

by

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SUMMARY

A lodgepole pine, stand-projection technique, called RMYLD (formerly LPMIST), developed for U.S.A. stands, was tested in the five interior British Columbia Forest regions, to develop a method of damage appraisal for dwarf mistletoe. In 1982, 114 plots, 78 with some mistletoe, were established, and mistletoe infection ratings, tree age and size measurements were recorded for over 5,000 trees. Using estimated 10 year height growth and radial increments, the projected growth from 1972 to 1982 was compared to the actual, current volumes for 50 representative plots, 4 to 21 per Region.

These comparisons indicated that the projection technique underestimated the volume growth per hectare. There was no apparent relationship between the differences when plotted against mistletoe infection rating, site index, stems per ha and average age. Predicted height growth and diameter growth were underestimated. Mortality, in terms of dead trees per ha, was less than that estimated by RMYLD. The relationship between percent trees infected and average mistletoe rating per plot was very similar to that found previously in the United States. These comparisons indicated that RMYLD did not accurately predict stand yields for B.C. lodgepole pine forests.

Due to the current uncertainties of site index curves in B.C., it was recommended that these data be reanalysed when curves are corrected. Further comparisons of actual to expected growth are desirable. In the meantime, the RMYLD technique should be useful to field personnel to determine relative or percentage effects of mistletoe on stand yield, and effects of thinning and other treatments on infected stands. A trial survey of mistletoe impact and an evaluation of silvicultural results of thinning using RMYLD would be desirable.

FOREWORD

Dwarf mistletoe is a major factor in the management of lodgepole pine throughout the province. Recent research results and field experience have shown that impacts of dwarf mistletoe can be greatly reduced by silvicultural practices. Most young infected lodgepole pine stands can be economically managed to obtain yields close to those expected from healthy stands on similar sites (Hawksworth, 1978a). Various combinations of juvenile spacing and pre-commercial thinning minimize effects of dwarf mistletoe on final yield. Forest managers need methods to evaluate the various options and combinations of treatments that are available to them to manage mistletoe-infected stands.

In 1982, Protection Branch commissioned a study of dwarf mistletoe, with particular attention to lodgepole pine. One recommendation (Laut 1982) was that the Ministry should investigate and eventually adopt a computer-assisted dwarf-mistletoe management system.

Subsequently, the senior author[1] investigated the suitability of a stand projection technique, RMYLD, that had been developed for dwarf mistletoe infested lodgepole pine stands in the Rocky Mountain region of the United States (Myers et al 1981, and Edminster, 1978a), for application in B.C.

This report is an edited version of the final contract report (Laut, 1984a) with some further evaluations of the results (Cameron 1984, Laut 1984b).

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[1] Forest Pest Management Advisor, Fort Collins, Colorado

INTRODUCTION

a) The RMYLD Stand Projection Technique

One of the first techniques for projecting stand growth that included a major pest, dwarf mistletoe, was LPMIST (Myers and others 1971), now included in RMYLD (Edminster 1978a). The technique was developed as a decision-making tool for mistletoe-infected pine stands. Given current stand conditions such as tree age, size, density, site index and dwarf mistletoe rating or intensity, and specifying treatments such as spacing, thinning and intermediate harvests, and their timing, the computer program projects stand growth over a selected rotation. Forest managers can test a variety of treatments and, based on the projected yields, choose one or more that best suit their management objectives.

LPMIST was originally developed for even-aged, pure lodgepole pine stands in Colorado and Wyoming. Following periodic updating and correction based on growth data from treated stands, it was incorporated as a subroutine in the program RYMLD (Edminster 1978a).

RMYLD is a whole-stand, distance-independent technique (Edminster 1978b) that utilizes conventional forest inventory data (metric or imperial units) plus simple measurements of dwarf mistletoe. It projects 10-year increment to reduce computation time. It has been adapted where necessary and adopted for use in Montana, Idaho and Central Oregon, by the U.S. Forest Service and other land management agencies. A similar program was developed (Dahms 1983) for lodgepole pine in Oregon.

b) Study Objectives

Although there are many yield projection and simulation programs (Edminster 1978b), the objective of this study was to determine if the RMYLD program was suitable for lodgepole pine stands in British Columbia infected by dwarf mistletoe (Arceuthobium americanum Nutt ex Engelm.)

A review of the mistletoe literature (e.g. Baranyay 1970, 1973, Hawksworth 1973, Muir 1972) suggested that mistletoe life cycle, biology and effects on host trees were similar throughout western North America, and that mistletoe relationships in RMYLD should be valid in British Columbia. Various growth and yield parameters in RMYLD were compared to B.C. plot measurements to test the performance of the program in B.C.

METHODS

The basic approach to test the validity of RMYLD as a stand projection technique in B.C. was to compare plot data measured in 1982 with RMYLD projected growth to 1982, based on 1972 plot conditions. Previous 1972 plot conditions were reconstructed from plot tree mortality, past 10-year height growth and past 10-year diameter growth at 1.3 m (dbh).

Plots were established in pure, even-aged lodgepole pine stands in central and southern interior B.C. with a range of dwarf mistletoe infection severity from nil to severe. Tree measurement data were summarized, projected using the RMYLD program, and analyzed using graphical and regression techniques.

a) Field Methods

Ministry of Forests personnel gathered field data required for this study after being trained in techniques that were required. Each region was requested to establish at least 30, and preferably 40, plots during the 1982 summer field season.

In early June, 1982, a dwarf mistletoe training program was presented to personnel from various districts during one-day sessions held at Burns Lake, Quesnel (for Prince George and Cariboo regions), Merritt and Creston. The program included:

i) slide-show and discussions on dwarf mistletoe biology, effects and control,

ii) outline of measurements and field form to be used, and

iii) field practice in dwarf mistletoe recognition, infection rating and plot measurements.

Because district crews were asked to assume this chore as an addition to their regular duties, it was agreed that each district would establish as many temporary plots as time allowed throughout the 1982 field season. The district protection officer, or equivalent, was responsible for getting the job done, checking the data sheets and forwarding them to the Regional Pest Management Coordinator or equivalent. If any difficulty arose, the authors were available to assist, advise or modify the procedures.

Plots, variable in size, were to include at least 50 trees. They were to be selected in a homogeneous stand of lodgepole pine in which dwarf mistletoe was of relatively uniform incidence, regardless of its level. Each district was requested to sample stands over the range of dwarf mistletoe levels, from healthy to severely infected. They were to select otherwise healthy stands, that is, no significant Atropellis canker or other visible diseases, and no current or recent mountain pine beetle-caused mortality.

Appendix 1 shows an example of the field form that was used. All measurements were in metric units, the standard operating procedure within the Ministry of Forests.

As indicated, most of the items to be recorded were standard usage for forestry. Some items, however, were different, as explained in Appendix 1.

b) Data processing and analysis

As field data sheets were received, plot descriptions and individual tree data were entered into a data base management system on a micro-computer. The plot descriptions and features were listed in a separate file (Appendix 2). Summaries of tree data per plot were prepared (Appendix 3) in a format suitable for input to the RMYLD program. The same mico-computer was used, via telephone, as an interactive terminal for RMYLD on the main-frame computer facility at Colorado State University, Ft. Collins, Colorado. General directions for using RMYLD on an interactive terminal are outlined in Appendix 4.

Diameters (dbh) in 1972 were calculated by subtracting double the radial increment from each measured dbh, and correcting for bark thickness using the formula (Myers 1964):

$$DBT\ (inches) = 0.038\ dbh\ (inches) + 0.115$$

Diameters were squared, summed and averaged to calculate quadratic mean diameter per plot. Height in 1972 was calculated by subtracting the 10-year height growth from the current height. Trees per hectare (density) were calculated from the number of trees and area per plot. Although it was specified that dead trees should be recorded, this was not done by many crews. Consequently, numbers and dbh of dead trees were not subtracted from 1982 measurements. Plot averages and standard deviations were calculated.

Average height of dominant and codominant trees was used to estimate site index (height at 100 years) based on current height-age curves for lodgepole pine (Ministry of Forests 1981). For comparison, plot site index also was calculated using Alexander (1966) curves. Projections by RMYLD use these curves (Alexander 1966).

Because it was impossible to measure the 1972 plot mistletoe rating (DMR), it was calculated using the DMR-increase formula in RMYLD. The 10-year increments for the ratings were:

DMR	INCREMENT
0.1 - 0.7	0.2
0.8 - 1.3	0.3
1.4 - 5.0	0.7
5.1 - 6.0	0.3

These increments were subtracted from the 1982 plot DMR to obtain the 1972 DMR.

Plot data were run through RMYLD twice: first as the plot was in 1972, reconstructed using recorded mortality on a hectare basis, past height and past DBH; and secondly as actually measured in 1982. No intermediate thinning treatments were specified and harvest (rotation) age was kept the same for each run. Harvest age was specified to ensure at least 4 or 5 ten-year increments were predicted for each plot. An example of the output tables for each plot is shown in Appendix 5, and tables for all plots are available on request.

RMYLD outputs were then entered back into the micro-computer data management system for compilation and analysis. Visitrend/Visiplot[1], a business analysis software package, was used to plot data and compute regression statistics. Predicted tree mortality, DBH, height, basal area, and volume for the 10 years from 1972 to 1982 were compared with the actual 1982 measurements. Total yields, at rotation, from both runs for each plot were also compared.

As plot data were run through the RMYLD program, it became apparent that there was considerable variation between predicted volumes for 1982 (from 1972 "measurements") and actual volumes calculated from 1982 measurements. Consequently, it was decided to proceed with only 50 plots for further analysis.

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1 Visitrend/Visiplot are copyrighted programs by Personal Software Inc.

These plots were selected to represent each Region and cover the range of dwarf mistletoe intensities.

RESULTS

a) Field Data

A total of 114 plots, 78 with mistletoe, were measured by regional crews with the exception of those in Nelson and Prince Rupert (Table 1).

TABLE 1 Distribution of dwarf mistletoe field plots in B.C.

Region and Districts	Number of Plots
Nelson	
Boundary	6
Cranbrook	7
Golden	8
Kootenay Lakes	3
Kamloops[1]	
Ashcroft	2
Clearwater	5
Kamloops	7
Lillooet	5
Merritt	5
Penticton	5
Salmon Arm	1
Vernon	6
Cariboo[1]	
Quesnel	4
Williams Lake	14
Prince George[1]	
Prince George West	3
McBride	7
Vanderhoof	7
Mackenzie	6
Prince Rupert	
Bulkley	5
Morice	8

Note 1. Plots established by regional crews.

Copies of the data sheets are filed at Protection Branch, Victoria. Plots and their physical descriptions were listed (Appendix 2) and a complete list is available from J. Muir, Protection Branch.

An example of the summaries of plot measurements, suitable for RMYLD input, is given in Appendix 3, and a complete summary is available from J. Muir.

b) Analyses

As the first step in examining the reliability of RMYLD, values predicted for 1982 from 1972 data (i.e., the first 10-year period) were compared with calculated values from 1982 data. In each case this "error" was obtained by subtracting predicted values from 1982 actual values (as calculated). These comparisons for diameter, height, basal area, volume and mortality for the sample plots are shown in Table 2.

In general, volume per hectare was underestimated by RMYLD as the actual minus predicted value was a positive number in all but 9 cases. The "error" in volume ranged from -153 to 377 cubic meters. These errors in volume as a percentage of actual volume showed no apparent trends when plotted against mistletoe rating, site index, density in 1972, and average tree age (Figure 1).

TABLE 2 Comparison of actual and predicted tree growth, 1972 - 1982, using RMYLD stand projection technique for selected plots

DISTRICT	PLOT	AVG. DMR	ACTUAL - PREDICTED VALUES: DBH(cm)	HT(m)	B.A.(m^2)	VOL.(m^3)	MORTALITY(t/ha)
BOUNDARY	5	2.0	5.0	1.1	12.8	154.5	558
CRANBROOK	2	1.2	2.4	2.35	6.8	48.0	-253
	3	2.0	1.4	1.4	29.5	56.3	-3269
	6	0.0	2.7	1.68	39.6	332.6	-569
	7	3.1	-3.0	0.15	7.8	49.4	-683
GOLDEN	1	0.0	6.1	1.6	27.5	271.7	142
	2	0.0	3.9	-0.2	21.3	226.7	-6
	3	0.1	2.2	1.9	6.3	108.6	425
	4	0.0	2.5	1.6	31.5	377.9	-544
KOOTENAY	1	2.1	2.6	3.1	4.1	80.3	59
CLEARWATER	1	0.0	2.4	0.9	11.9	123.0	332
	2	0.0	2.4	1.1	23.0	191.6	-262
	3	0.0	1.5	0.9	7.4	80.2	-27
	5	0.0	1.5	1.1	1.3	26.3	105
KAMLOOPS	1	2.4	3.6	4.7	18.3	278.9	53
	4	4.3	4.7	1.8	-6.7	-52.3	4
	5	0.0	1.8	0.9	23.9	138.3	273
	8	0.0	-1.4	-0.1	-3.5	-11.5	-99
	9	0.0	2.8	0.8	33.8	210.5	378
LILLOOET	2	3.6	1.9	0.4	0.1	2.4	288
	3	0.0	-0.2	0.0	-0.2	-0.3	-86
	5	0.0	2.1	0.7	22.9	99.0	-617
MERRITT	5	1.6	2.4	2.6	7.7	55.1	994
PENTICTON	1	0.0	-1.1	1.3	-4.8	-16.5	708
	2	0.0	3.4	0.2	10.3	50.6	75
SALMON ARM	1	0.0	1.8	0.2	0.8	12.5	218
VERNON	1	0.0	3.8	1.1	10.3	132.1	196
	2	4.9	-2.7	1.1	-13.9	-152.9	156
	3	1.4	1.3	-1.06	3.4	9.3	275
	4	0.6	-0.2	-1.31	-9.1	-129.5	294
	6	0.0	-3.9	0.7	-3.2	-7.1	-32
WILLIAMS LK.	7	4.5	-0.7	4.7	-2.0	48.9	7
	8	5.2	2.8	2.2	6.8	90.2	136
	11	0.0	2.7	0.0	20.0	82.8	229
	12	1.3	6.7	0.43	13.8	119.6	157
QUESNEL	2	2.2	2.0	1.6	12.0	112.8	506
	3	0.0	2.9	1.9	18.3	187.5	240
WILLIAMS LK.	1	4.0	2.2	2.7	6.3	80.1	-2
	2	3.2	-0.2	1.9	-2.8	16.7	123
PR. GEORGE	2	4.2	3.0	2.4	17.5	106.2	-215
	3	3.1	-0.0	2.2	-1.9	14.6	67
McBRIDE	17	3.8	2.0	0.6	4.2	41.1	50
	21	3.3	0.3	-0.2	-1.3	-18.6	53
MACKENZIE	15	1.0	3.7	-0.4	20.9	216.1	93
BULKLEY	1	4.4	1.7	0.89	3.1	241.3	119
	2	0.0	3.8	1.3	19.3	139.7	215
	4	0.0	-3.0	0.7	-14.8	-100.8	137
MORICE	3	0.0	2.8	0.9	13.1	113.5	122

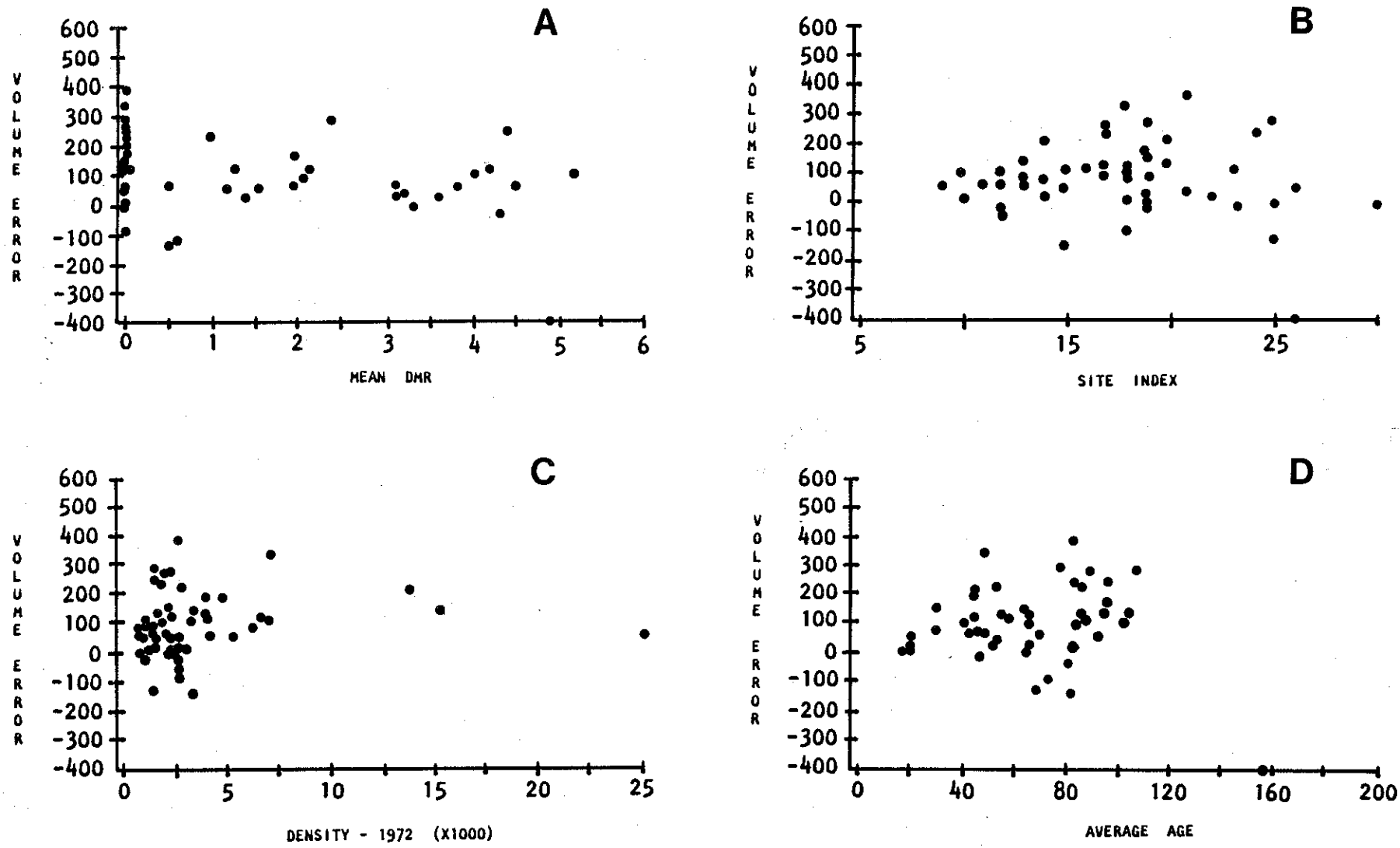

Figure 1. Volume error (%) between actual and estimated 1982 values per plot for: (A) Mean dwarf mistletoe rating, (B) site index (m), (C) Density (stems per hectare) in 1972 and (D) Average age of dominant and codominant trees.

Similarly, the "errors" for the other components of stand growth of height (Fig. 2), diameter (Fig. 3), and mortality (Fig. 4) showed, with a minor exception (Fig. 3D), no trends when plotted against DMR, site index, density, and average height.

Generally both height and DBH growth were underestimated. No trends were apparent when basal area errors (Fig. 5) were plotted against site index (A) or average age (B). Mortality (Fig. 4) was overestimated by RMYLD, but no trends were apparent .

A comparison of the plot site index as calculated originally using Ministry of Forests (1981) curves and subsequently using Alexander (1966) curves is shown in Table 3. The percentage error in projecting plot stand volume (actual 1982 volume minus predicted volume for 1982 divided by actual 1982 volume multiplied by 100) was reduced using Alexander (1966) curves, but was still variable.

TABLE 3 Comparison of actual and projected stand volume in 1982, based on two methods of determining plot site index

District (plot number)	Site Index (m)[1] original	new	Volume Error (%)[2] original	new
Golden (1)	17	19	54	51.7
Golden (2)	24	25	41	27.2
Clearwater (1)	18	22	27.1	19.4
Clearwater (5)	19	25	26.3	0.0
Kamloops (5)	20	25	42.8	29.0
Williams Lake (11)	13	17	43.4	32.4
Bulkley (2)	13	17	47.3	40.1

Notes 1. Site index "original" was calculated using Ministry of Forests (1981) curves and "new" using Alexander (1966) curves.
2. Volume error % was actual minus predicted volume for 1982 divided by actual 1982 volume multiplied by 100.

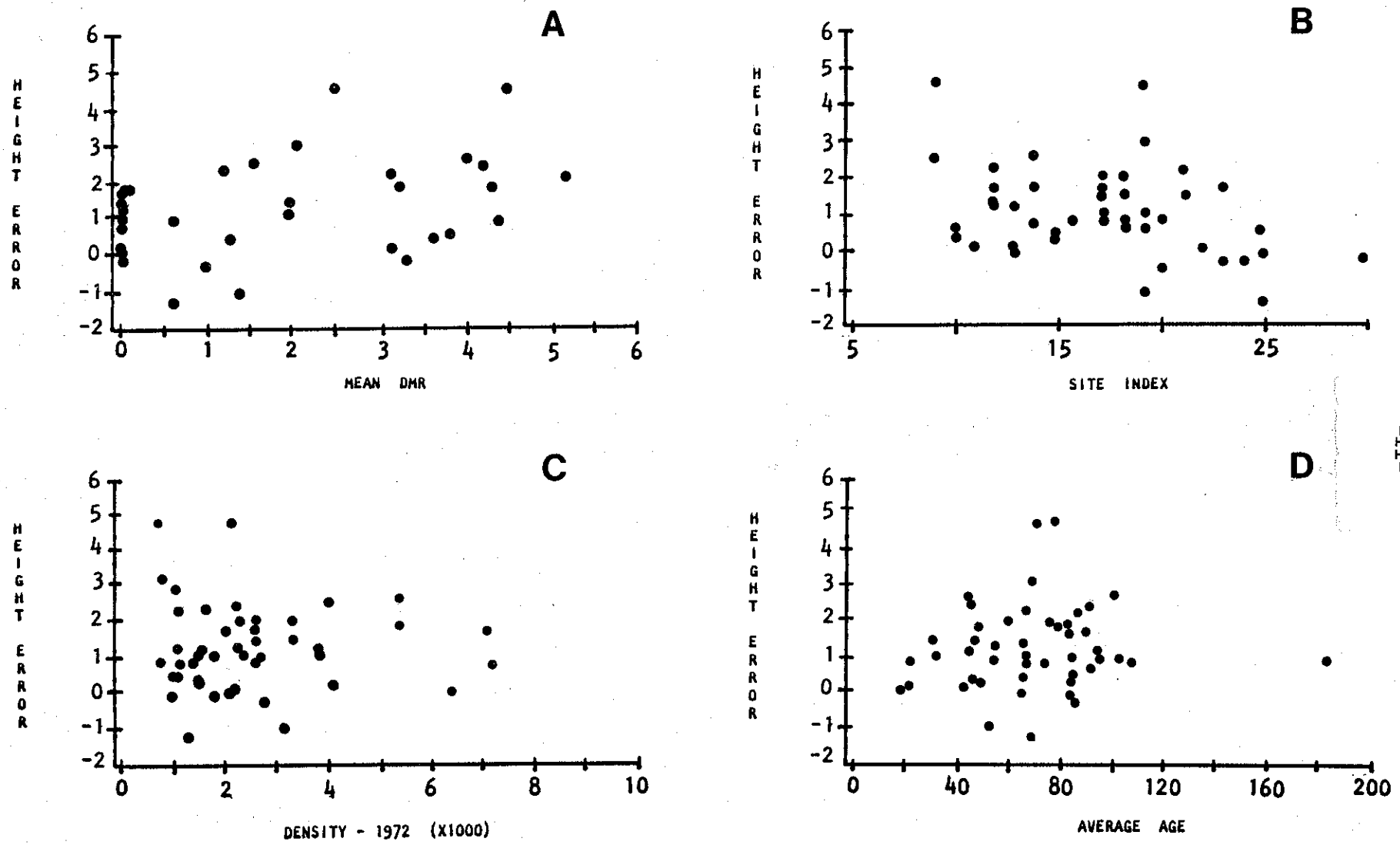

Figure 2. Height error (m) between actual and estimated 1982 values per plot for: (A) Mean dwarf mistletoe rating, (B) site index (m), (C) Density (stems per hectare) in 1972, and (D) Average age of dominant and codominant trees.

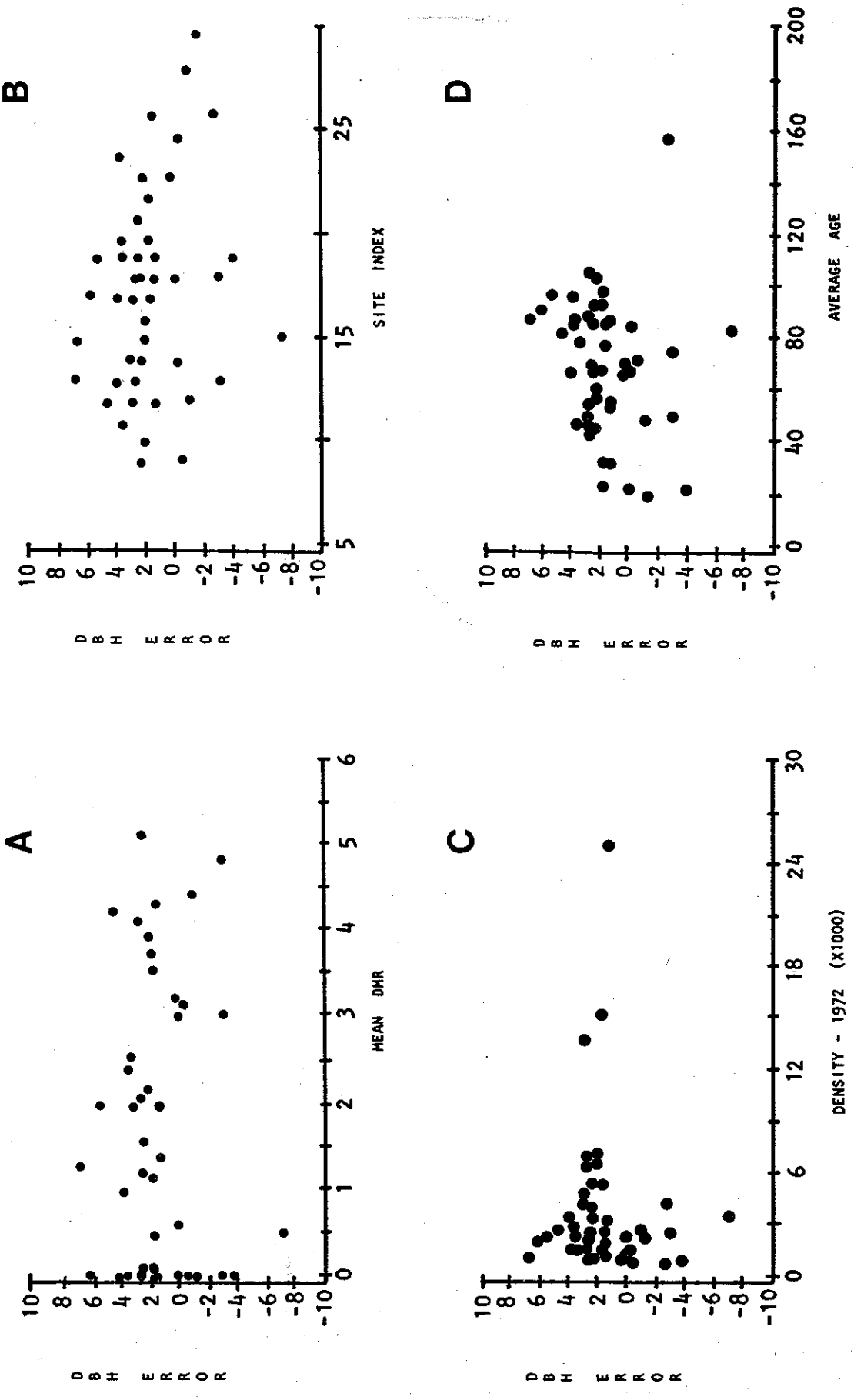

Figure 3. Diameter (dbh, cm) error between actual and estimated 1982 values per plot for: (A) Mean dwarf mistletoe rating, (B) site index, (m), (C) Density (stems per hectare) in 1972, and (D) Average age of dominant and codominant trees.

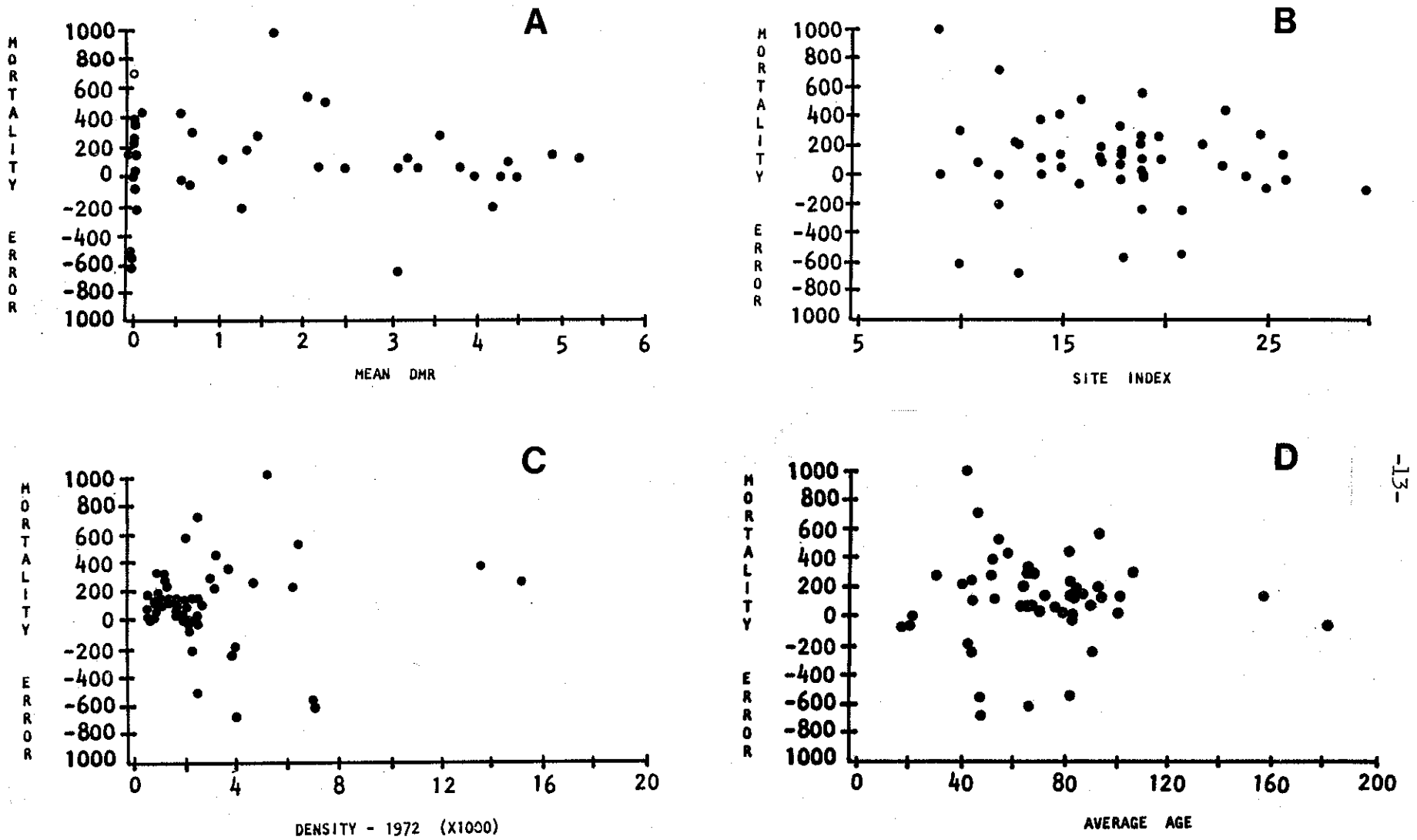

Figure 4. Mortality error (stems per hectare) between actual and estimated 1982 values per plot for: (A) Mean dwarf mistletoe rating, (B) site index (m), (C) Density (stems per hectare) in 1972, and (D) Average age of dominant and codominant trees.

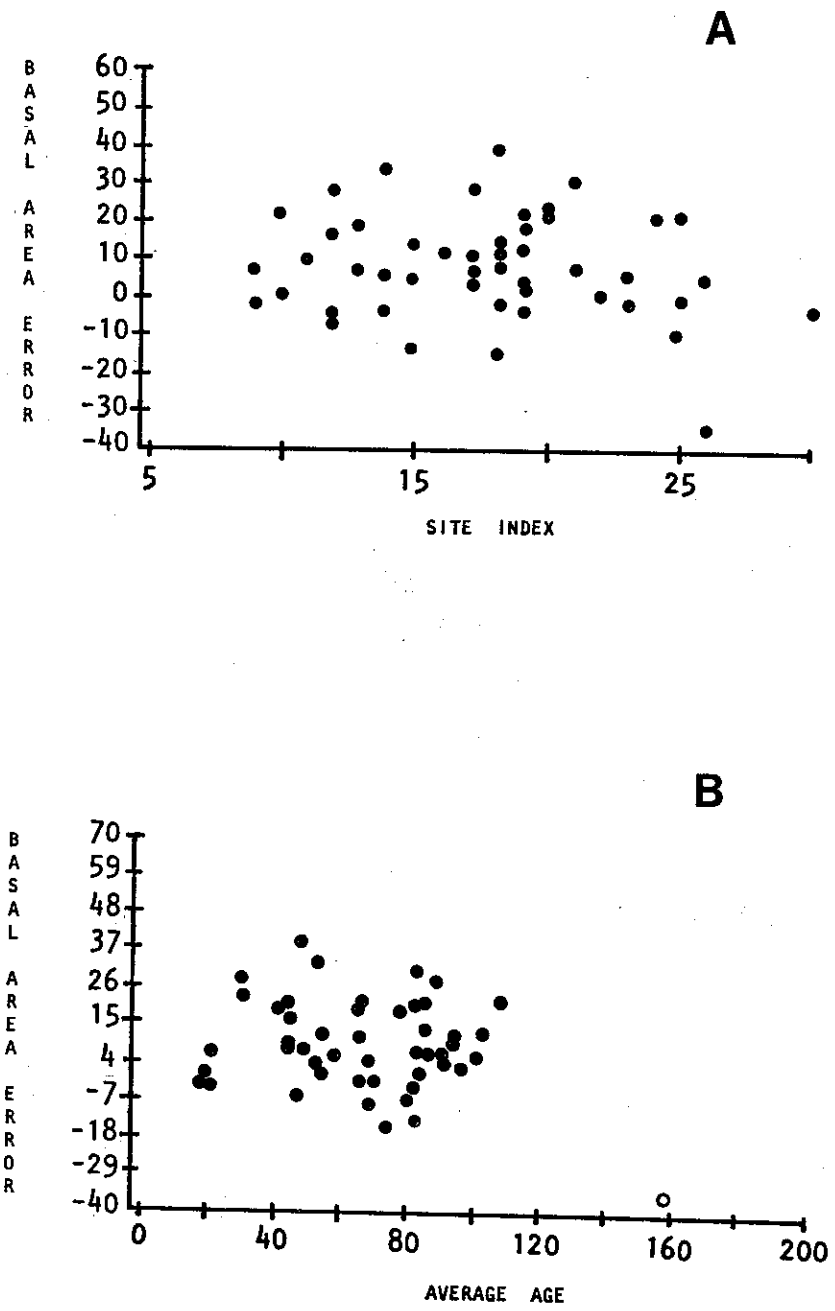

Figure 5. Basal area errors between actual and estimated 1982 values per plot for: (A) site index (m) and (B) Average age of dominant and codominant trees.

c) Dwarf mistletoe effects

For B.C. data, the relationship between percent trees infected (X) and plot mean dwarf mistletoe rating (Y) as a base-ten logarithm, shown in Figure 6, was:

$$Y = -0.863 + 0.014\ X$$

with a correlation coefficient (R^2) of 0.885. This was very similar to the equation (Hawksworth 1977) used in RMYLD:

$$Y = 0.8814 + 0.014\ X$$

Results shown in the Figures indicated no apparent relationship between dwarf mistletoe rating (DMR) and errors of prediction for volume (Figure 1A), height (Figure 2A), dbh (Figure 3A) and mortality (Figure 4A).

DISCUSSION

From these data and analyses, RMYLD does not appear sufficiently accurate to use directly to project stand volumes of lodgepole pine in B.C. In general, volume is underestimated. The error between actual and predicted values in 1982, based on projections from reconstructed plot conditions in 1972, varied widely from plot to plot (Table 2 and 3) with no trends or relationship to stand characteristics (Figure 1 to 5). The underestimation of volume using RMYLD resulted from underestimated diameter and overestimated tree mortality. Mistletoe effects appeared similar in B.C. and did not result in these errors, judging from the similar errors and variation in data from 23 plots which had no dwarf mistletoe.

Initial plot site index was an important datum to project stand volume as shown (Table 3) by the reduced error in projected volumes when Alexander (1966) height-age curves were used instead of the Ministry curves (1981). However, the errors were still too extreme to be acceptable. Perhaps when new, suitable height-curves for B.C. have been adopted, these data should be re-analyzed.

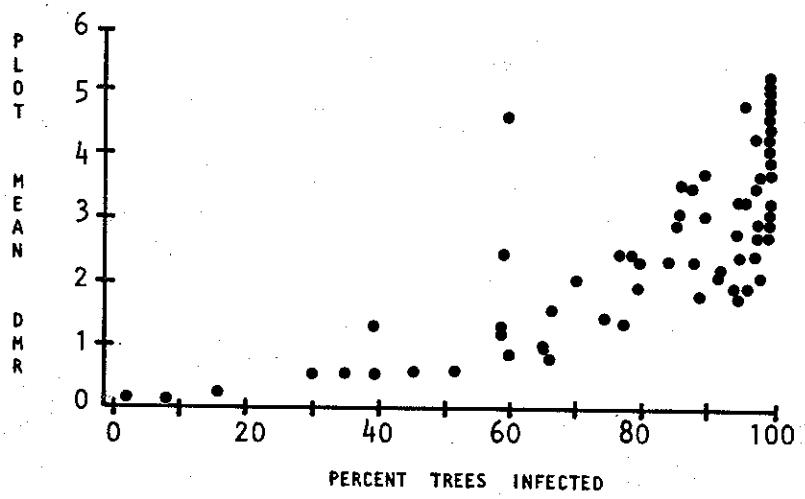

Figure 6. Relationship between percent trees infected by dwarf mistletoe rating (DMR) per plot.

The relatively small errors in predicting height growth, suggested that methods used here to estimate 10-year height growth were sufficiently accurate. However, stem analyses would improve the accuracy of height predictions.

Only a slight difference was found between the relationship of plot mistletoe rating (DMR) and percent trees infected in B.C. compared to the curve used in RMYLD. This variation was perhaps due to the inexperience of field crews in using the mistletoe rating system, but it does illustrate the ease with which the system can be learned and applied consistently. RMYLD uses DMR, not percent infected trees, as the rating is more accurate and easy to determine (Hawksworth 1977).

Although RMYLD is not sufficiently accurate, it probably can be used in conjunction with B.C. stand volume tables to project the effects of silvicultural treatments on stand growth and yield (Edminster 1979a). The program costs 15¢ per run, assuming the data are organized beforehand. Another desirable application in conjunction with damage appraisal surveys (e.g. Johnson and others 1981, Van Sickle and Smith 1978, Drummond 1982), is to determine effects of mistletoe on forest productivity in Districts, Regions, and province-wide. These data should enable the Ministry to propose and analyze the effects of mistletoe control programs in timber supply areas, and to set priorities for mistletoe and other stand treatments.

RECOMMENDATIONS

1. RMYLD should be installed on the Ministry computer system for training, educational and pest damage survey purposes.

2. A trial damage survey and evaluation of a mistletoe control program using RMYLD is desirable.

3. Further work to refine or calibrate RMYLD for B.C. conditions is needed to accurately project stand volume, pending resolution of appropriate site index curves for B.C. Alternatively, mistletoe subroutines could be calculated for currently used Ministry techniques, such as TASS. Possibly Regional versions of RMYLD might improve accuracy of estimates.

ACKNOWLEDGEMENTS

Many people contributed to this project. Pest Management Coordinators in the five interior Forest Regions, and their staff, accepted responsibility for the field work and coordinated District activities, including arranging office and field sites for the training programs, and assuring that Districts were represented. They also funded and supervised the field work in Prince George, Cariboo and Kamloops Regions.

Drs. Frank Hawksworth and Carl Edminster (U.S. Forest Service, Rocky Mtn. Forest and Range Experiment Station) provided advice and reviewed the report (Laut 1984).

We particularly appreciated the co-operation of District and Regional staff, who, at short notice, willingly provided their assistance to acquire the field data.

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Appendix 1 Sample Field Form

A sample of the form used to record field plot data is attached.

Data items required were those commonly used in forestry, with the following exceptions or definitions:

LOCATION - UTM coordinates as commonly used by Ministry of Forests.

HABITAT TYPE - zone and ecosystem association as per current ministry or regional definition.

DMR - Dwarf Mistletoe Rating, based on the system (Hawksworth 1977) where each tree is given a rating from 0 (no visible dwarf mistletoe) to 6 (more than half of all branches in live crown with visible infections). RMYLD accepts this rating as a basic input for calculations, although it also accepts other measures of dwarf mistletoe such as percent of stand infested or age of stand when first infested. DMR provides the most accurate results and is the most widely accepted measurement of dwarf mistletoe intensity. Special attention to this rating was given during the training sessions and field exercises.

PAST HT. - Past height, measured to the 10th branch whorl down from the top of the tree.

HT. TO CROWN - Distance from ground to the first live branch.

AGE COUNT - Age, determined from increment core taken at breast height (1.3 m).

TOTAL AGE - Age count plus the standard Ministry of Forests correction factor for age to grow to breast height.

10 YR. INCR. - Radial increment (mm), measured from increment core taken at breast height for the past 10 years.

25%, 50%, 75% - These columns were provided for the field to indicate, according to their judgement, which trees would be removed if the stand was to be thinned by the percent indicated.

LODGEPOLE PINE DWARF MISTLETOE SURVEY

REGION_____DISTRICT_____RECORDER_____DATE_____PLOT#____PG__/__

LOCATION: S_____ T_____R_____ ELEVATION_____m SLOPE____% ASPECT____

PLOT DIMENSIONS: W_____m, L_____m, or RADIUS_____m. AREA _____ha. factor___

HABITAT TYPE :_____ DEAD TREES(10 years)#_____ REGEN#_____

COMMENTS:

#	DBH	DMR	Ht.	Past Ht.	Ht. growth	Ht.to crown	Cr class	Age count	Total Age	10yr Incr.	25%	50%	75%	Notes

Appendix 2 Plot Descriptions

Copies of the plot descriptions are available from J. Muir, Protection Branch.

These computer print-outs include plot location, elevation, slope, aspect, area, number of trees, number of dead trees, number of regenerating trees, habitat type and notes.

DWARF MISTLETOE PLOTS - PHYSICAL AND ECOLOGICAL DESCRIPTIONS

REGION: 1 NELSON REGION

DISTRICT	PL	LOCATION-UTM	ELEV	SLOPE	ASPECT	AREA	NO.OF TREES	#DEAD	#REGEN	HAB.TYPE	PLOT NOTES
BOUNDARY	1	115432-421	1400	18	S	*010	50	3	0	ICH C2	
BOUNDARY	2	115432-421	1400	40	S	*010	50	5	0	TCH C2	
BOUNDARY	3	115497-354	1242	0	S	*010	50	3	1	ICH L2	
BOUNDARY	4	115503-356	1500	15	S	*050	60	27	8	ICH L2	
BOUNDARY	5	115503-356	1500	13	S	*050	75	38	5	ICH L2	
BOUNDARY	6	115489-363	1210	10	S	*030	50	18	7	ICH C2	BEAVER CR.RD.2
----- T O T A L S FOR BOUNDARY -----											
CRANBROOK	1	115610-5495	975	3	N	*100	52	0	0		
CRANBROOK	2	115900-5466	1238	20	SW	*040	76	13	0		
CRANBROOK	3	?	1350	0	0	*003	76	0	0	MSA	FLATHEAD
CRANBROOK	4	?	914	0	N	*040	69	16	0	JDFB3	PERRY CREEK
CRANBROOK	5	?	1580	8	SW	*040	76	13	10	ESSAFA	COTTON-TIE CRK
CRANBROOK	6	?	1275	0	0	*014	98	1	7	SA	NEGRO CRK.
CRANBROOK	7	/	1340	0	E	*015	62	0	18	MSA	GOLD CRK.
----- T O T A L S FOR CRANBROOK -----											
GOLDEN	1	1104845-5708	3250	0	0	*053	98	9	13	ICHA2 4C	BLUEWATER
GOLDEN	2	1104795-5747	3000	5	S	*034	53	6	9	ICH A2 1C	BUSH RIVER
GOLDEN	3	1105225-5665	3250	0	0	*018	45	14	0	IDF G3 4C	MALLARD CRK.
GOLDEN	4	110524-56785	1200	18	S	*021	50	4	0	MSA 4C	
GOLDEN	5	110554-5648	4500	5	N	*036	54	8	16	MSA 3C	KOOTENAY RIVER
GOLDEN	6	110504-5700	3250	30	SE	*046	55	6	12	ICH A2 1C	BLAEBERRY R.
GOLDEN	7	110497-5680	4300	0	0	*053	67	2	7	ICH C2 1C	CANYON CRK.
GOLDEN	8	114290-57580	1490	30	SE	*048	51	14	0	ICH A2 1C	SULLIVAN R.
----- T O T A L S FOR GOLDEN -----											
KOOTENAY LAKE	1	115840-54307	1225	15	SW	*080	54	5	2	1C HC 2	
KOOTENAY LAKE	2	115858-54298	1250	14	S	*090	63	16	5	1C HC 2	
KOOTENAY LAKE	3	115392-54696	1610	38	SW	*090	51	12	0	ESS FC	
----- T O T A L S FOR KOOTENAY LAKE -----											
----- T O T A L S FOR NELSON REGION -----											

Appendix 3 Plot Data Summaries

Copies of plot averages used as input for RMYLD and copies of plot data are available on request from J. Muir, Protection Branch. A sample is attached.

APPENDIX 3

PRESENT AND PAST PLOT DATA TO BE USED AS INPUT FOR RMYLD
NOTE-ALL MEASUREMENTS ARE IN METRIC

REGION: 1 NELSON REGION

PLOT#		SITE INDEX	AGE	TREES/HA	QUAD.M.DBH	AVG.HT.	DMR	%INFECTED
1	PAST(1972)DATA	17	66.2	5300	12.9	13.9	ADJUST	
	PRESENT(1982)	17	76.2	5000.0	14.6	16.7	0.1	8
2	PAST(1972)DATA	17	66.4	5500	10.6	12.7	ADJUST	
	PRESENT(1982)	17	76.4	5000.0	13.9	16.4	0.2	16
3	PAST(1972)DATA	19	47.2	5300	10.4	13.3	ADJUST	
	PRESENT(1982)	19	57.2	5000.0	15.6	15.8	3.4	96
4	PAST(1972)DATA	20	81.8	1740	18.1	18.0	ADJUST	
	PRESENT(1982)	20	91.8	1200.0	21.2	20.6	3.1	90
5	PAST(1972)DATA	19	86.0	2260	~~16.2~~ 17.9	17.5	ADJUST	
	PRESENT(1982)	19	96.0	1500.0	22.0	19.9	2.0	86
6	PAST(1972)DATA	22	82.0	2267	19.6	18.1	ADJUST	
	PRESENT(1982)	22	92.0	1666.7	12.5	11.2	3.6	98

Appendix 4 Directions for RMYLD users

A copy of a computer print-out plus comments is attached to guide a user of RMYLD in the interactive mode or system.

Once into the program in interactive mode you are faced with a series of input questions for variables, written in fortran acronyms. A translation of these, with entries for an example run in parentheses, follows. Items in all UPPER-CASE are as you see them on the screen of your terminal. Note that a question mark (?) follows each question or instruction and is a prompt for your response.

"YOU'LL NOW USE FREE-FIELD DATA INPUT. YOU MUST BE AWARE THAT: (1) A VALUE MUST BE ENTERED FOR ALL VARIABLES REQUESTED (EVEN IF IT'S ZERO). (2) THE VALUES MAY BE SEPARATED BY SINGLE COMMAS OR ONE OR MORE BLANKS. AND (3) YOU SHOULD ENTER DECIMAL POINTS IN VALUES WHERE NECESSARY, E.G., THE VALUE THREE-POINT-ONE SHOULD BE ENTERED AS '3.1' AND NOT '31', WHILE THREE MAY BE ENTERED AS '3', '3.', OR EVEN '3.Ø'.

**IS YOUR CARRIAGE WIDTH 8Ø OR 132? ? (8Ø)

** DO YOU WANT YOUR TABLES PRINTED TO ANOTHER FILE? ? (NØ) If your printer is in a remote location you should answer "Y" and specify directions.

** ENTER VALUES FOR MIN AND MOUT. ? (1,1) This response specifies metric units as input and output. Ø's specify English units. The program actually operates with English units. Metric input is converted for operation and then output is reconverted if metric output is specified. Rounding errors can result.

**** BEGIN INPUT FOR STAND NO. 1 ****

**ENTER AS A DECIMAL THE PERCENT OF THE STAND ACREAGE WHICH IS STOCKABLE. ? (1)

** ENTER AS A DECIMAL THE PERCENT BY WHICH TOTAL YIELDS SHOULD BE REDUCED DUE TO DEFECT. ? (Ø)

** ENTER VALUES FOR IDSPP, COMCU, COMBF. ? (2 999 999) IDSPP is species code, 2= lodgepole, 4=Englemann spruce-subalpine fir, 5= aspen. Other species currently included are not represented in B.C. COMCU and COMBF set cutting constraints for commercial cuts, i.e. the specified volume must be present for a scheduled cut to be implemented. If metric units were specified (above) COMBF is ignored. In this example high limits were specified to ensure unlimited activity.

SINCE YOU ARE DEALING WITH LODGEPOLE PINE, IT IS ASSUMED THE STAND IS EVEN-AGED. ONLY VALUES FOR THE OVERSTORY WILL BE REQUESTED.

** ENTER VALUES FOR ICUT(1),LIMSAW(1). ? (9 1) ICUT specifies the number of scheduled cuts that are precommercial. LIMSAW is a flag that enforces COMBF. It has no effect when in metric option, thus it can be either 1 or Ø.

** ENTER STAND DESCRIPTION (UP TO 45 CHARACTERS) - IDSTND. ? (NELSON,BOUNDARY#1) Identify your stand.

** ENTER VALUES FOR PER(1), PER(2), PER(3). ? (Ø 1Ø 1Ø) These variables allow setting of the first three growth cycles. The value of the third entry is carried for the remainder of the projection period.

** ENTER VALUE FOR SITE INDEX. ? (17) Site indeces should be on a base age of 1ØØ years.

** ENTER VALUES FOR AGEO(1), DBHO(1), HTSO(1), DENO(1), BASO(1). ? (76 13.9 16.4 5ØØØ Ø) These variables define the initial stand statistics - age, DBH, height, density as trees per hectare and basal area. Any two of DBHO, DENO or BASO must be entered. The program will calculate the missing one. Note- DBHO and HTSO sre averages (DBH should be quadratic mean) of dominant and codominant trees only.

** ENTER VALUE FOR DMLEV. ?(6) This is the upper level of dwarf mistletoe intensity, as DMR, above which scheduled thinnings will not be performed. It is user specified and can be any number up to 6.Ø

** ENTER VALUES FOR DMR(1), PINF(1), START(1), IOPT(1). ? Ø.2 Ø Ø Ø The first three variables are alternative ways of entering current dwarf mistletoe level. DMR is the preferred, but PINF (percent of trees infected) is acceptable. START is the age of stand when infection first began, and is difficult to estimate. It is commonly used in theoretical exercises. In healthy stands, START must be set at an age greater than rotation or you will get an unexpected infestation rampaging through your stand. IOPT is a "flag" that sets initial thinning of infected stands as above (Ø) or below (1).

** ENTER VALUES FOR DELAY(1), JCYCL(1), THIN(1). ? 1ØØ 1ØØ 23 These variables begin the process of defining your density management regime. DELAY is a time period between "now" and the first scheduled thinning. JCYCLE is the time interval between subsequent thinnings. Both these variables should be multiples of 1Ø. THIN is thespecified basal area to be left after the first thinning.

** ENTER VALUES FOR DSTY(1,1), DSTY(1,2), DSTY(1,3), DSTY(1,4). ? 23 23 23 23 These are residual densities following subsequent thinnings. Implementation was defined by JCYCLE. If more than 4 thinnings are scheduled the last DSTY will prevail.

** ENTER VALUES FOR INCDEL, INCTHN, INCDST, INCJCY, INCGSL, IBAGSL. ? 1 1 1 1 1 1 Variables with a prefix INC generate multiple yield tables by incrementing the indicated variables. Be careful! If each of these was set to 4, you would get 5^4 tables!-- a lot of paper. IBASGL is a flag that specifies residual stocking to be interpreted as basal area (1) or GSL (Ø).

** ENTER VALUES FOR THNADD, DSTADD. ? Ø Ø These specify the amount to increment residual densities if INC variables (above) have been set higher than 1.

** ENTER VALUES FOR REGN(1,1), VLLV(1,1), REGN(1,2), VLLV(1,2), REGN(1,3). ? 12Ø Ø Ø Ø Ø These allow specification of reproduction method and rotation age. REGN sets the age of regeneration cut. VLLV is a percentage of the last DSTY set prior to the start of regeneration. For example, if the REGN's were set at 8Ø, 1ØØ, 13Ø, and VLLV's set at Ø.7 and Ø.3 you would get a three step shelterwood cut with a prep. cut at age 8Ø to 7Ø% of DSTY, a seed-cut at 1ØØ to 3Ø% of DSTY and a final removal at age 13Ø.

** ENTER VALUES FOR IDELR(1), IHRVST(1), IABOVE(1). ? Ø Ø Ø IDELR initiates an INC sequence in the reproduction method. IHRVST is a flag which interprets VLLV- Ø specifies VLLV as a % of DSTY, 1 specifies VLLV as % of basal area immediately prior to the first reproduction cut. IABOVE is a flag that specifies whether reproduction cuts are from above (1) or below (Ø).

At this point the program takes over;

HERE WE GO...

1YIELDS PER HECTARE OF LODGEPOLE PINE
NELSON, BOUNDARY#1

SITE INDEX 17.0 M. 100-YEAR THINNING INTERVAL
THINNING INTENSITY-- INITIAL- 23.0 SUBSEQUENT- 23.0,
23.0, 23.0, 23.0
VALUES IN TABLE ADJUSTED FOR 1.000 STOCKABLE AREA AND 0.000 DEFECT.

CHARACTERISTICS BEFORE AND AFTER THINNING

STAND AGE YEARS	DMR	TREES NO.	BASAL AREA SQ.M.	AVERAGE D.B.H. CM.	AVERAGE HEIGHT M.	TOTAL VOLUME CU.M.	MERCH. VOLUME CU.M.
76	.2	5000	76.0	13.9	16.5	601.1	195.9
86	.4	815	12.5	14.0	17.4	109.0	36.5
96	.6	808	17.3	16.5	18.3	159.3	104.3
106	.9	806	21.8	18.5	19.1	209.3	168.3
116	1.2	806	26.1	20.3	19.8	260.7	226.5
120	1.5	806	27.4	20.8	20.1	277.4	244.6
			TOTAL YIELDS			277.4	0.0

THINNING INTENSITIES ARE BASAL AREA VALUES NOT GSL"S.
MERCH. CU. M. - TREES 15.2 CM. D.B.H. AND LARGER TO 10.2-CM. TOP. MINIMUM COMMERCIAL LIMITS-- 999.0 CUBIC METERS PER HECTARE.
INITIAL THINNING FROM ABOVE ALLOWED IN STANDS WITH DWARF MISTLETOE.
D.M.R. ABOVE WHICH PERIODIC THINNINGS WILL NOT BE EXECUTED - 6.0.
ALL THINNINGS MAY BE NONCOMMERCIAL. REMOVALS WERE RESTRICTED TO SAWTIMBER
** DO YOU HAVE ANY MORE STANDS YOU WISH TO PROJECT? ? (N)

Appendix 5 RMYLD - Projected Stand Growth Tables

Copies of the RMYLD output tables per plot or stand are available on request from J. Muir, Protection Branch. A sample output is attached.

1YIELDS PER HECTARE OF LODGEPOLE PINE
NELSON,KOOTENAY LK#1,1972

SITE INDEX 19.Ø M. 1ØØ-YEAR THINNING INTERVAL
THINNING INTENSITY-- INITIAL- 23.Ø SUBSEQUENT- 23.Ø, 23.Ø, 23.Ø, 23.Ø
VALUES IN TABLE ADJUSTED FOR 1.ØØØ STOCKABLE AREA AND Ø.ØØØ DEFECT.

CHARACTERISTICS BEFORE AND AFTER THINNING

STAND AGE YEARS	DMR	TREES NO.	BASAL AREA SQ.M.	AVERAGE D.B.H. CM.	AVERAGE HEIGHT M.	TOTAL VOLUME CU.M.	MERCH. VOLUME CU.M.
59	1.4	737	18.1	17.7	16.2	146.9	112.Ø
69	2.1	734	23.2	2Ø.1	17.8	2Ø7.3	178.5
79	2.8	724	27.8	22.1	19.1	267.2	242.3
89	3.5	694	31.1	23.9	2Ø.2	316.6	292.7
99	4.2	647	32.8	25.4	21.1	348.8	326.8
1ØØ	4.3	642	33.2	25.7	21.2	355.5	333.3
			TOTAL YIELDS			355.5	Ø.Ø

1YIELDS PER HECTARE OF LODGEPOLE PINE
NELSON,KOOTENAY LK#1,1982

SITE INDEX 19.Ø M. 1ØØ-YEAR THINNING INTERVAL
THINNING INTENSITY-- INITIAL- 23.Ø SUBSEQUENT- 23.Ø, 23.Ø, 23.Ø, 23.Ø
VALUES IN TABLE ADJUSTED FOR 1.ØØØ STOCKABLE AREA AND Ø.ØØØ DEFECT.

CHARACTERISTICS BEFORE AND AFTER THINNING

STAND AGE YEARS	DMR	TREES NO.	BASAL AREA SQ.M.	AVERAGE D.B.H. CM.	AVERAGE HEIGHT M.	TOTAL VOLUME CU.M.	MERCH. VOLUME CU.M.
69	2.1	675	27.3	22.7	21.Ø	287.6	263.1
79	2.8	665	31.Ø	24.4	22.3	348.1	322.6
89	3.5	638	34.3	26.2	23.4	399.5	375.Ø
99	4.2	596	35.9	27.7	24.2	428.3	4Ø3.4
1Ø9	4.9	539	36.1	29.2	24.9	438.Ø	413.8
11Ø	4.9	531	35.6	29.2	24.9	432.Ø	4Ø8.1
			TOTAL YIELDS			432.Ø	Ø.Ø