

**A PEST SURVEY IN YOUNG STANDS
IN THE PRINCE RUPERT FOREST REGION**

by

Laing & McCulloch
Forest Management Services
Smithers, 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

A strip survey was conducted on a variety of site and stand types within the Prince Rupert Forest Region to determine incidence levels of pests occurring in young conifer stands (10-70 years of age). A total of 104 units were sampled and mapped.

Original plot data were reviewed, corrected and then entered on a computer. Data were compiled to produce 76 tables of incidence. The focus of data analysis was to summarize incidence rather than analyze relationships between variables or trends in data. Significant levels of incidence were noted for a number of pests, including Warren's root collar weevil, stem rusts, *atropellis* canker, *pinneus* aphids, and, in localized areas, white pine weevil and agents causing foliage and bud damage. Requirements for further data analysis as well as recommended changes to survey procedures have been summarized under the Recommendations section.

The information provided in this report is expected to provide regional protection personnel with a tool for planning future management activities as well as for establishing research priorities.

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1 INTRODUCTION

1.1 Background

Field work was started in late July, 1986 and was completed by October 5, 1986. The field sampling portion of the project was conducted jointly by Laing & McCulloch and A.J. Stock Forest Management Services. Data review and synthesis were conducted from October 20, 1986 to March 31, 1987.

1.2 Objectives and Scope

The objective of the project was to determine the incidence of damaging agents in stands less than 70 years of age in the Prince Rupert Forest Region. This information will be used to determine priorities for further research and will also serve as a data-base for program planning and budgeting.

2 METHODOLOGY

2.1 Field Procedures

Basic field procedures and standards were defined by ministry personnel in the original tender package. Minor modifications were then incorporated in the final contract following suggestions made by the consultants in their proposal. Because these procedures had not been previously tested in the field at an operational level, a number of changes were also made after field trials. These changes were significant enough that data collected for the first five units could not be meaningfully included in subsequent analysis and were, therefore, excluded.

The process used for collecting stand data included eight phases, summarized as follows:

1. MoF, Prince Rupert Forest Region, Protection personnel selected a variety of stands throughout the region. Rough location maps and aerial photos were provided for each stand. Stands were selected considering access and location relative to each other as well as expected productivity of field workers.

A range of biological criteria were also applied to the process of selection. Wherever possible, stands in each forest district were chosen so that naturally and artificially established types were sample. To provide some flexibility in workload, more stands were identified by regional personnel than required. The final selection was, therefore, made by the consultant. A total of 84 stands were sampled.

2. Aerial photographs were reviewed for each stand. One or two five-hectare units were then delineated in each area based on stand size and site type. Only one unit was delineated per stand unless substantial variation in topography and vegetation patterns occurred.
3. A sample line 200-1 000m in length was established on the aerial photo for each unit prior to entering the field. Lines were generally continuous and ran at an oblique angle to the contour. Certain photo lines were not practical in the field and were modified on site prior to sampling. Lines were discontinued if they ran through non-representative brush pockets or swamps. Generally, wetter, brushy ecosystem associations were avoided.

The length of the sample line was based primarily on the time allocated to complete the unit. A manday productivity of two units was required. Where possible, a long sample line was used for units exhibiting greater variability.

Sample lines were established in multiples of 100m, each 100m being one plot. The beginning and end of each plot were marked with flagging ribbon and identified by black felt marking on the ribbon. Ribbons were also hung at intervals along the length of the plot.

4. Data were collected on field cards. All live trees greater than one-third the height of crop trees and within five metres of the sample line were inspected for visible evidence of pest problems. All dead trees, regardless of size, were also noted.

In many cases, even though there were no visible crown symptoms, roots were inspected on a random basis in areas, or with tree species known to have, or to be susceptible to, particular insects or diseases. When this type of random sampling showed that root pests were present but crown symptoms were not yet apparent, all trees within 20m of the plot were sampled, regardless of above-ground conditions. Information obtained in this way was extrapolated for the whole plot. Residual trees, established before the existing stand, which occurred within 20m of the sample line, were also inspected for pest damage and recorded where damage was evident. Fire-killed snags, however, were not noted.

Ten variables were recorded for each plot: damaging agent; species attacked; status of the tree (live standing, live down, dead standing, dead down, dead or broken top); average age of the tree; location of damage (leader, bud, stem, branch, foliage, or root); geographical area in which damage occurred (TSA), subzone in which damage occurred; subzone in which the damage occurred; ecosystem association in which damage occurred; type of stand in which the tree occurred (natural, planted, managed, non-managed); and the relative date of damage (current, older, current and older). Information under the ADMIN column was equally applicable to all trees within a plot. Information to the left of the map column was normally recorded on a tree specific basis. Where frequent repetition of a particular pest on a given tree species occurred, however, the set of conditions was recorded only once and the number of trees so affected was indicated under # on the plot card.

To facilitate inspection of field work by MoF personnel, the location of damaged trees was shown on a map grid on the card. Each square represents two square metres.

5. Damage to trees was only noted if:

- it affected 30% or more of the circumference of the stem and/or was 30cm in length along the stem;
- it affected 30% or more of branches or foliage;
- it affected the leader, root collar, and/or roots in any way.

All occurrences of stem cankers or stem rusts were recorded, regardless of size. Additionally, if a rust occurred on a branch within three centimetres of the stem, it was recorded. If the rust was greater than three centimetres away, more than 30% of the branches had to be affected for it to be noted.

Dwarf mistletoe was always recorded. The standard 6-point dwarf mistletoe rating system was used and recorded beside the C or O symbol under the mistletoe column.

6. At 100m intervals along the strip line the number of stems per ha and tree species composition were determined. Initially, a variable radius plot was established, such that eight to ten trees were recorded (the radius changed from plot to plot depending on stocking). However, it was found to be more efficient to simply use a standard 3.99m radius plot (1/200th ha), and this system was adopted for the majority of sampling. The number of stems by tree species was recorded in each plot.

This type of system does not yield a statistically reliable estimate of either composition or stocking. In many cases when it was clear that the plot did not represent the stand, an estimate of stocking and composition was made by the surveyor. The fact that it was an estimate was noted on the card.

7. One root sample (>10cm in length) was collected in each unit for each root species disease found. In addition, whenever uncertainty arose with respect to the identity of agent of damage, a sample was collected and labelled using a Canadian Forestry Service Forest Insect and Disease Survey Sampling Form. These samples were submitted to the regional pathologist, who shipped them to Pacific Forest Research Centre in Victoria for analysis. Responses were mailed back to Laing & McCulloch. Leo Unger, a Forest Insect and Disease Survey Ranger, also spent some time reviewing collected samples.
8. A final important aspect of data collection procedures was the ongoing communications maintained with regional Protection staff. Communications were frequent and conducted in person because the consultants were locally based.

2.2 Data Collection and Compilation Procedures

The purpose of this phase of the project was to summarize collected data so that pest incidence could be clearly stated for a given set of parameters. In this report, 10 parameters were used. For example, the incidence of the pine pitch moth (*Petrova albi-capitana*) was noted for each TSA, subzone, ecosystem unit, stand type, tree species, age class, tree status, location of damage, and relative time at which damage occurred. When any of these parameters changed, a new summary of incidence was produced. Incidence was reported with four indices: average live stems per ha affected, percentage of live stems affected, average dead stems per ha, and percentage stems killed by the agent. However, since incidence was summarized by so many parameters, there were very few samples for any given set of parameters. Thus, regression analysis at this level was not significant.

The process of reducing 6 772 rows of data, 214 characters wide (not including Bulkley Units 1-5) to 76 tables of incidence was time consuming, even with the aid of a fixed disk drive installed on the computer. Data manipulation was performed using the Lotus 1-2-3 software package. The basic process can be summarized as follows:

1. Pest identity changes were made on the actual field cards once samples had been reviewed by the Pacific Forest Research Centre and returned.
2. Errors in consistency were changed (to facilitate review of field cards by MoF personnel).
3. Each entry on each plot card was entered on the computer. Portions of the data were subsequently coded to facilitate compilation and sorting. For example, ecosystem association was categorized as mesic, submesic or dryer, or subhygric or wetter and assigned the number 1, 2, or 3 accordingly. Age class was categorized as 0-20, 21-40, and 41, and again assigned a 1, 2, or 3 coding.
4. Data were then collated, through a series of sorts, such that plot entries were organized by TSA, Subzone, Ecosystem Class, Stand Class and Age Class.
5. A series of mathematical calculations were conducted to compile and simplify data within each plot.
6. A second series of mathematical calculations were performed to compile all plots within each criterion range.
7. A third set of mathematical calculations were conducted to determine average stems per ha affected and average percentage affected for each pest, tree species, tree status, location of damage, and time of damage.

8. This final level of information was then reorganized into tabular format and a paper copy produced for each of the 76 tables of incidence.

When interpreting data in these tables a number of important points and assumptions must be understood. Firstly, data were only summarized for the most important pest occurring on an affected tree. Where more than one agent was noted, only the most damaging was used in subsequent calculations. The relative importance of damage for various combinations of agents was determined jointly with the regional pathologist and the consultant.

Secondly, as was stated earlier, stand stocking/composition plots were not reliable indicators of actual stand composition. As a result, in some cases, pest damage was recorded as having occurred on a particular tree species in a plot, when stand composition information did not include that species as a component of the stand. Therefore, it was not possible to calculate percent incidence. When this kind of combination occurred it was assumed that the tree species represented an insignificant component of the stand, and so a zero was entered under average percentage affected. However, stems per ha affected were still calculated and stated.

Again, because stand composition information was somewhat unreliable, in a few cases more stems of a given tree species were affected by a particular pest than the stand composition information indicated were available to the affected. In other words, percentage incidence was greater than 100. In these cases, the average composition for all plots in the unit was used rather than only the composition for the associated plot in the percent calculation.

A fourth important point to consider when interpreting data tables is that total live stems per ha were not measured in the stand stocking/composition plot; rather, only those trees at least one-third the average stand height were measured. Pest incidence was also noted only on trees greater than one-third of average stand height. However, all dead trees were recorded. Therefore, to express average percentage dead for a given pest and trees species it was necessary to divide total dead trees by total living trees greater than one-third the average stand height (determined from the associated stocking/composition plot). This results in an overestimation of the percent mortality resulting because of a particular pest. A more accurate expression of mortality would have been to divide total dead trees by total living trees + total dead trees. Actual percentage dead, therefore, will be something less than what is recorded under this column.

A fifth important characteristic of the data to note is that no information is provided relative to the percentage of residuals in a stand affected by a given pest. This is because total residual stems per ha were not measured or recorded.

Finally, living trees which were windthrown were recorded and presented in the final table within parentheses as a separate category. Calculations relative to incidence were, therefore, performed separately for these trees.

2.3 Mapping

For each unit sampled, a 1:10 000 or 1:20 000 scale map was produced delineating plot locations. Photocopies of the original access maps provided by the MoF were used as base maps. Plot locations were transferred from aerial photos or field maps and highlighted in red. The point of commencement (PoC) was also shown. A legend was provided at the bottom of the map stating associated forest district (TSA), general location, unit number, number of plots, data surveyed, and the surveyor's initials.

The relative location of all units was also marked on a separate 1:600 000 scale Ministry of Environment map. Unit location was indicated by a yellow circle with the unit number written inside it.

3 PRODUCTION AND PRODUCTIVITY

3.1 Production

Production in the field is summarized in Table 1 below.

TABLE 1 SUMMARY OF FIELD WORK

Item	North Coast	Kalum	Kisplox	Bulkley	Morice	Lakes	Total
No. of 100m plots	15	43	45	98	44	46	291
No. of units (Sha blocks)	7	19	18	22	19	19	104
Average plots/unit	2.14	2.26	2.50	4.45	2.30	2.42	2.80
No. of stands	7	17	15	16	16	13	84

Subsequent to the field work, each entry on each field card was recorded on a series of floppy disks. A total of 7 620 rows of data, each 214 characters wide, were recorded. After review and data correction a lengthy series of sorts and mathematical compilations were conducted to produce 76¹ tables of incidence (see Appendix B).

3.2 Productivity

A total of 69 ten-hour mandays were required to complete the field work portion of the contract. Average productivity was, therefore, 4.22 plots/manday. This figure includes time spent preparing for the field work by redesigning sampling procedures, producing the field cards, training by the regional pathologist, reviewing maps and pre-stratifying the aerial photos, and meeting with regional staff during the pre-work conference and field work review.

Productivity in the field was significantly lower than that originally anticipated because of:

- a) a higher proportion of pest problems occurring below ground than estimated (the survey was basically designed for visual identification of symptoms or pests above ground);
- b) inaccurate maps and difficult access;
- c) more abiotic and old unknown damage than anticipated.

¹ Does not include Units 1-5 (848 rows of data) from the Bulkley TSA.

The data synthesis and collation phases of the project again proceeded more slowly than anticipated. Manhours expended are summarized as follows:

Data revision	24.0 hours
Entering plot data on the computer	131.5 hours
Map production	48.0 hours
Sorting and compilation	180.0 hours
Data print-out	28.0 hours
Report preparation and review	30.5 hours
Package finalization and revisions	<u>56.0 hours</u>
Total	<u>498.0 hours</u>

A total of 62 eight-hour mandays were required to produce the final product.

3.3 Cost Summary

The budget for the project was \$25,000.00. Manpower requirements accounted for the largest proportion of expenditure. Costs are summarized below in Table 2.

TABLE 2 COST SUMMARY

Materials	171.19
Food	256.15
Accommodation	310.30
Vehicle and transportation	615.70
Meetings, correspondence, training and pre-organization	1 728.13
Field work	15 918.53
Data analysis	4 957.80
Report preparation and revisions	<u>1 042.20</u>
Total	<u>\$25 000.00</u>

4 RESULTS AND DISCUSSION

4.1 The Product

Items provided as part of the final submission include:

- 338 field cards representing 291 plots
- 88 CFS insect and disease sampling forms
- seven floppy disks of corrected original field data
- a 132-page paper print-out of the corrected original plot data
- 104 1:10 000 or 1:20 000 scale plot location maps
- one 1:600 000 scale unit location map
- two floppy disks containing collated levels of incidence in tabular form
- a paper print-out of the tabulated incidence levels
- a separate legend for both the original data tables and incidence tables
- the report.

The incidence tables summarize pest damage by tree species, damaging agent, location of damage, and time of damage for each specific set of five different variables (TSA, subzone, ecosystem association class, stand class, and age class). Broader scale trends and relationships derived from these tables are discussed in the following section.

4.2 Apparent Relationships

Without the benefit of an in-depth analysis of the data or substantiation of the reliability of observations through analysis of variance techniques, a discussion of results is less meaningful. Nonetheless, a number of observations and apparent relationships are worth highlighting.

4.2.1 Lodgepole pine and associated pests

- Lodgepole pine is a relatively high risk species. A number of damaging agents can cause both mortality and growth loss.
- *Hylobius warrenii* (HYWA) was widespread in young pine stands (1-20 years) in the Kispiox, Morice, and Lakes Forest Districts affecting 2.1%, 4.3%, and 7.3% of total live pine trees, respectively. Some level of HYWA was recorded

in 94% of all plots located in these stands in the three forest districts. In older age classes the incidence of root collar weevil was more variable but could, on average, affect as many as 6.5% (Kalum) or 12.6% (Lakes) of all live pine.

- Except in the North Coast and Kalum Forest Districts, stem rusts were normally present, at least at low levels, in most pine stands 20-60 years of age. Rust infections were recorded in 93% of all plots located in pine stands in this age class in the Kispiox, Bulkley, Morice, and Lakes Forest Districts. Average percentage incidence in live pine in these forest districts was 0.6%, 2.7%, 1.7%, and 10.7%, respectively. Average mortality varied from 0.1% in the Kispiox Forest District to 2.6% in the Lakes Forest District. In localized areas, stem rusts were responsible for significant growth loss and mortality. In one stand in the Lakes Forest District, 17.6% of live trees were affected and 6.7% of the pine component of the stand had been killed by rusts.

It was also noted that rust incidence was frequently high in stands which had already been spaced to reduce stocking and to remove infected trees. In one selection of 20 different plots, an average of 8% of the remaining trees was still infected following spacing. This type of residual incidence should be accounted for when determining target stocking levels during spacing operations.

- *Atropellis piniphila* (ATPI) was infrequent in stands less than 40 years of age. In older pine stands, incidence was high — in some areas averaging 19.3% in the Kispiox Forest District, 1.6% in the Bulkley Forest District, and 31.4% in the Lakes Forest District. Only one pine stand older than 40 years of age was surveyed in the Morice Forest District, and ATPI was not present. Mortality resulting from this canker was rare, averaging less than 1.0% in the interior and transitional forest districts, and 0.0% in other forest districts.
- The occurrence of *Pissodes terminalis* (PITE) was negligible in the North Coast and Kalum Forest Districts. In the Kispiox, Bulkley, Morice, and Lakes Forest Districts, in 10-40 year old pine stands, incidence in live pine trees averaged 3.4%, 1.3%, 3.7%, and 2.9%, respectively. Consecutive attacks were rare, however, and the impact on growth and stem quality was considered minimal.
- *Petrova albicapitana* (PEAL) did not significantly affect pine stands, except in the Kispiox Forest District, where it affected an average of 8.9% of live pine trees. In two localized areas, incidence was very high at 60.6% and 50.0%. There was no apparent explanation for these abnormally high levels of attack. In the other forest districts, stands affected by PEAL were either rare or absent.
- Dwarf mistletoe in young pine stands was not noted during the survey. Root rots were also infrequent in these stands.

4.2.2. Spruce and associated pests

- The incidence of pest damage in spruce was also relatively high, although mortality levels were low.
- A problem common to all six forest districts was terminal and lateral bud mortality resulting from the effects of frost, unspecified diseases, and unspecified insects. For stands which had a significant spruce component, average incidence levels (expressed as percentage of live spruce trees affected) are summarized below:

	Frost	Disease	Insects	Total
North Coast	0.0	5.9	0.0	5.9
Kalum	0.2	0.3	0.2	0.6
Kispiox	2.8	3.4	0.1	6.3
Bulkley	1.9	3.2	0.9	6.0
Morice	1.1	2.1	0.6	3.8
Lakes	3.1	0.2	0.0	3.4

Bud mortality often caused a year's growth loss and/or multiple stem formation.

Except in the Kalum Forest District, bud mortality from all causes was heavier in planted stands than in natural stands. Bud mortality was noted in 59% of all planted spruce stand types but in only 21% of natural spruce stand types. This relationship and its causes may warrant further study.

- *Pinneus* aphid (PIN*) was not observed on Sitka or hybrid spruce (North Coast and Kalum Forest Districts), but was noted in 58-70% of all plots where interior hybrid spruce formed a significant component of the stand. Actual incidence levels in these stand types were low, except in the Morice Forest District, where an average of 13.8% of all live spruce was affected. Incidence in the Kispiox, Bulkley, and Lakes Forest Districts was 2.0%, 1.7%, and 0.5%, respectively. Very little mortality was attributable to *pinneus* aphid.
- *Pissodes strobii* (PIST) incidence levels were low in all forest districts, except the Kalum. Average incidence levels in stands where spruce was a significant component ranged from 0.0% to 0.7% in the North Coast, Kispiox, Bulkley,

Morice, and Lakes Forest Districts, and 11.0% in the Kalum Forest District. Eighty-six percent (86%) of all plots located in spruce stands were noted to have some PIST damage in the Kalum Forest District. Three of 17 stands in this forest district incurred multiple attacks and probably suffered some growth loss. No mortality was attributable to PIST anywhere in the region. It appears that further study of this pest in the Kalum Forest District is warranted to determine factors associated with heavy attack stands and the effect on tree growth.

- The incidence of root rots in young stands was lower than anticipated. It is possible that this is related to weakly-expressed visual symptoms in early stages of infection in these stands. Neither *Inonotus tomentosus* (POTO) nor *Armillaria ostoyae* (ARME) were noted in the North Coast and Kalum Forest Districts. ARME was also absent in the Kispiox and Lakes Forest Districts. Average incidence for ARME in stands with a significant component of spruce was 0.3% in the Bulkley and 0.01% in the Morice. Average POTO incidence levels were 0.3%, 0.5%, 0.5%, and 0.1% for the Kispiox, Bulkley, Morice and Lakes Forest Districts, respectively. Mortality resulting from these diseases also averaged less than 1.0% for all spruce stands.

Where POTO did occur, incidence was highest on submesic and subhygric sites (1.3% - 5.4% for individual stands) and lowest on mesic sites (0.1% - 1.1% for individual stands). Infection may, therefore, be stress related. ARME infections showed similar trends.

- Hybrid spruce also served as a host to HYWA in some mixed stands. In one stand in the Kispiox Forest District, 5.8% of all live spruce were affected, and in another older stand in the Morice Forest District 4.1% of live trees were affected and an average of 40 trees per ha were killed.

4.2.3 Western hemlock and associated pests

- Dwarf mistletoe was infrequently noted in young western hemlock trees. It was recorded in only three stands at incidence levels of 2.5%, 6.3%, and 24.0%. In these cases, it was related to infected residual trees within the stand. Because information on this pest is relatively abundant and occurrences are infrequent, it has a low priority for further study.
- In stands where hemlock was a significant component, mechanical damage to the stem, branches, or leader was noted in 92%, 82%, and 78% of all plots in the North Coast, Kalum, and Kispiox Forest Districts, respectively. In these three forest districts it affected an average of 0.6%, 1.4, and 0.9% of all live hemlock trees. Damage from an unknown agent to the stem, branch, leader, or foliage was even more significant affecting 13.7%, 7.1% and 10.2% of total

live hemlock in the three forest districts. Incidence levels within individual stands were as high as 40%, affecting up to 3 800 stems per ha.

- The incidence of root rots was low, although in two stands *Armillaria ostoyae* and *Heterobasidion annosum* were noted to have caused some mortality (1.9% and 2.3%, respectively). Stem rots were also occasionally found in these young stands.
- Two other minor pests occurred in hemlock. The first was porcupine damage which, in the Kalum Forest District, was recorded in 82% of all plots containing a significant component of hemlock. The average incidence was only 0.9% of total live trees and never exceeded 2.5% in any individual stand. Porcupine damage to hemlock was not significant in other forest districts.

The second minor pest was an unknown stem canker recorded in 31% and 33% of all plots in the North Coast and Kalum Forest Districts. Average incidence levels were low, however, at 0.3% and 1.6% of total live trees, respectively.

4.2.4 The true firs and associated pests

- *Amabilis* fir was recorded only in the North Coast Forest District. It was a relatively scarce species therein, and was not noted to be a significant component in any of the stands. The average stem per ha affected for all stand types was 6.7 trees. Damage was old in 86% of these cases, and the damaging agent was unknown.
- Subalpine fir was rare or non-existent in stands sampled in the North Coast and Kalum Forest Districts. In the interior forest districts (Bulkley, Morice, and Lakes), it appears that it is a relatively high risk species as a young tree in stands where it is a minor component and is adjacent to ungulate habitat. Ungulate damage was noted in 47% of all plots sampled in these three Forest Districts. In plots where it occurred in sufficient numbers to form at least a minor component of the stand, an average of 3.6% of all live subalpine fir suffered ungulate damage. Forty-five percent (45%) of these had suffered repeated attacks. Eventually it will grow beyond browse height, but may be set back several years before achieving this.
- Foliage and bud diseases were the second most common problem in subalpine fir. In the Kispiox, Bulkley, Morice, and Lakes Forest Districts, foliage or bud diseases were noted in 43% of all plots sampled. In those plots where subalpine fir occurred in sufficient quantities to qualify as a significant component of the stand, an average of 2.2% of all live trees were affected.

- *Armillaria ostoyae* (ARME) was recorded in some subalpine fir stands in the Kalum, Bulkley, and Lakes Forest Districts. It was noted only in 21-40 year old stands, and distribution was patchy. In some stand types (natural, managed) up to 2.5% of live subalpine fir stems were infected. The average live stems per ha infected in "natural, managed" stands in the Kalum Forest District was 7.1 trees. These sites were not ideal for the species (submesic and mesic), suggesting that the potential for infection is stress related. On "natural, non-managed" stands in the Lakes and Bulkley Forest Districts, however, infection did occur on sites suited for the species (although at lower levels — 0.1% of live subalpine fir trees). Some mortality was also attributable to ARME. In the Kalum and Bulkley Forest Districts, for 20 different plots, an average mortality level of 3.3 stems per ha could be attributed to *Armillaria* root disease.

4.2.5 Western redcedar and associated pests

- Monocultures of cedar are uncommon in the Prince Rupert Forest Region. Cedar was normally recorded only as a minor component and occurred only in the North Coast, Kalum, and Kispiox Forest Districts.
- The most frequent type of damage was to the stem or leader from an unknown agent. This type of damage occurred in 33 of the 104 plots established in the North Coast, Kalum, and Kispiox Forest Districts. An average of 11.3 stems per ha was affected, representing 1.9% of total live cedar trees.
- Little other significant damage was noted on cedar, although an abiotic agent (probably frost) affected 9.1% of live trees in one stand and 42.3% of live trees in another stand. A foliage disease also affected 33% of live trees in a third stand. None of the remaining 12 stands was affected by these agents.

4.2.6 General observations

- Pest problems were generally more severe in the interior and transitional zones than on the coast. Conversely, brush problems were more severe on the coast and appear to be more significant there than pest problems.
- The most common entry under "agent" was "unknown." Leader damage and old forks were very common, but it was usually impossible to identify the damaging agent because of the time lapse since attack. This was also true with older dead trees, which had usually been infected with a variety of decay organisms following death.
- A final point is that defoliators were not a significant contributor to damage in young stands in the region.

4.3 General Recommendations

It is recommended that, wherever possible, the Tables of Incidence (Appendix B) be used by MoF personnel as a basis for further analysis.

For a given TSA, subzone, ecosystem association class, stand class, and age class, the average incidence of a particular agent on both live and dead trees is stated in the Tables of Incidence (Appendix B). The location of pest damage on the tree and its relative date of origin are also stated. Based on current standards for acceptable levels of incidence, Protection personnel can, therefore, determine if a particular pest merits further attention within a given TSA. An estimate of the impact on stocking levels can also be obtained and, where relationships between incidence levels and tree growth have been previously established in other studies, an estimate of impact on growth loss can be made. In cases where this relationship has not been established, incidence levels determined in this study will at least indicate for which pests or tree species the highest priority exists to establish the relationship.

To determine the types of relationships described above on a broader scale will require further data manipulation. These broader data trends or summaries are often important tools in management planning and budgeting and should, therefore, be addressed. More specifically, it is recommended that:

- Pest incidence (and potential impact) be summarized and depicted in either bar or pie charts for each TSA and the region as a whole.
- Pest incidence levels be summarized for each tree species within each TSA as well as for the region as a whole.
- A regression analysis be performed to determine if a relationship exists between: subzone and pest incidence; ecosystem association and pest incidence; stand class and pest incidence; and age and pest incidence for each tree species as well as for all tree species combined. Where it is reliably indicated that a relationship exists, it should be shown graphically (note that at these broader levels of analysis the number of sample points is greater and confidence levels should also be higher).
- A regression analysis be performed to determine if specific or general pest incidence is related to the occurrence of residuals within a unit.

Data could also be summarized in a number of other ways as well, and some of the points made under section 4.2 could be tested for statistical validity.

The basic method of strip sampling for general pest incidence is useful and reasonably efficient. However, a number of procedural changes are recommended to economize time and improve the accuracy and quality of information collected during future surveys of this nature.

- Reduce the range of age classes sampled to 10-40 years.
- Reduce the range of stand classes sampled excluding, for example, "planted and subsequently managed stands."
- Reduce the strip width to five metres.
- Record stocking by tree species twice every 100m by establishing a 3.99m radius circular plot. The plot location should be chosen by the surveyor as representative of the immediate area and an inventory component label should be estimated to the nearest five percent.
- Residuals should not be recorded and stands with a heavy residual component (selectively logged stands) should be avoided.
- Mapping of affected stems should not be required.
- All site types, including brush areas, should be surveyed but stands which were clearly never sufficiently stocked should be avoided.
- Only trees which are one-third the height of surrounding crop trees or could potentially attain crop tree status should be measured. This includes both live and dead trees as well as trees measured in the stocking plot.

The volume of information provided from this survey is substantial and MoF personnel should be prepared to spend sufficient time to review it for results and trends pertinent to perceived regional needs. Particular attention should be given to the contribution pest occurrence might have on the creation of backlog NSR lands. If further data collection or analysis requirements are identified, these should be defined before the 1987 field season. Protection personnel at the forest district level should also be informed of general results and future information requirements.