A REVIEW OF PEST - DAMAGE SURVEY METHODS FOR YOUNG TREES AND BACKLOG REFORESTATION AREAS IN BRITISH COLUMBIA

March 1986

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Forest Service Internal Report
PM-PB-32

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FOREWORD

This report is one of a series distributed by Protection Branch to record accomplishments on pest control projects. These reports are distributed for the information of staff, colleagues and others who may be interested in the interim or provisional results.

The enclosed review of pest-damage survey methods was based on a report for the Forest Resources Development Backlog Reforestation Research Project 1.9, prepared by F. Einfeldt, Industrial Forestry Service, Prince George, and edited by J. Beardsley, Victoria. Protection Branch and Regional staff, and Silviculture Branch staff, provided considerable information, reviews, and effort to prepare this report.

The work reviewed here was a useful basis to develop and conduct pest surveys of young trees in the Prince George and Prince Rupert Forest Regions in 1986-87. These surveys were conducted with FRDA Pest Control funds. Subsequently, many of the recommendations of this report have been or are being implemented. However, the views expressed in the report are not necessarily those of the B.C. Ministry of Forests and Lands or the FRDA Management Committee Members.

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SUMMARY

In 1985, as an initial step in developing pest-damage surveys for young stands and plantations, operational and published survey methods were reviewed. A variety of general forestry and silvicultural surveys were examined. Only a few of these surveys, with modifications, appeared suitable for recording pest damage to young trees.

In 1985, surveys were most often performed on mature trees before harvest, on newly regenerated areas, and on selected young stands before spacing. Further surveys appeared desirable to detect pest conditions in not satisfactorily restocked (NSR) areas and in stands older than an age suitable for spacing.

Although several pest-specific survey methods were available for young trees, the methods were too specific to include the wide range of pest damage that could be expected in northern young stands. A more general pest damage survey was recommended for use with silvicultural pre-harvest, regeneration, and spacing surveys.

The reader should note that from 1985 to 1988, several modifications were made to the operational silvicultural surveys, and many now include pest data and information. Also, opinions expressed by the contractor are not necessarily those of the B.C. Forest Service.

RECOMMENDATIONS

Based on a review of the literature available in 1985, the following recommendations were made:

- Procedures for timber cruising, silvicultural pre-harvest prescription, silviculture stocking surveys, and free-growing surveys should be modified to include more pest-damage information as an option.

- A standard pest code should be developed for use by the B.C. Forest Service and the Canadian Forestry Service to:

  - identify or categorize each pest;
  - provide information for each pest on its occurrence and effects such as incidence, degree of infestation, rating of intensity of attack or damage, and potential for tree recovery from attack or damage.

- A general pest damage survey be developed for young stands after the free-growing surveys.

- A general procedure be developed to identify areas that require a pest-specific survey.

- Depending on the economic significance of the damage, and the need for data, specific pest damage surveys should be developed for other potentially important pests of young trees such as stem rusts and cankers, needle diseases or defoliators, animal damage, bud insect pests, and leader weevils.

- A reference guide should be developed to assist field personnel in recognizing pests and their damage to young trees, and to facilitate making prescriptions for tree or site treatments to prevent or reduce damage.

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1. STUDY PURPOSE AND OBJECTIVES

In 1985, Research Project 1.9 of the Backlog Reforestation Program of the Forest Resources Development Agreement was undertaken to review methods for determining pest damage in young plantations and natural stands in northern interior British Columbia.

In developing the terms of reference for the project, the co-ordinators recognized four possible situations where pests and/or pest damage could result in not satisfactorily restocked (NSR) stand conditions:

- an area becomes NSR because of pest damage (e.g., black army cutworm defoliates and kills seedlings; root disease kills seedlings and prevents re-establishment of conifers);
- an area becomes NSR because pest damage is promoted by a site treatment (e.g., prescribed burning results in black army cutworm infestation);
- a young stand that appears acceptable is already infested and becomes NSR because of pest damage (e.g., dwarf mistletoe on residual trees; leader weevil deformities); and
- a stand must be surveyed for pest infestation before harvest to determine the threat to the new, young stand (e.g., root rot infestation on brush-prone sites).

Pest survey methods should be developed for, or be adaptable to, these situations.

There were some survey methods available for individual pests such as leader weevil and root disease in coastal stands. However, none appeared suitable to encompass a wide range of various pest damage - some possibly of unknown causes - that might be encountered in a single plantation.

At the time of the project, several silvicultural surveys were available for determining stocking and regeneration performance, but most appeared to have little or no provision for detailing pest damage. The contractor was therefore directed to review what pest survey methods were available, and how pest damage information might be accommodated within current surveys for the pests or damage that could be anticipated in northern young forests.

The reader should note that concurrently or after this review, several operational surveys were modified and, in 1988, they now include provisions for pest damage, particularly the pre-harvest silvicultural prescription. Also, opinions and recommendations of the contractor in this report are not necessarily those of the B.C. Forest Service.

2. GENERAL FOREST SURVEYS

2.1 Timber Cruise

Timber cruising is a long-established, province-wide survey procedure primarily designed to provide statistically sound timber volume estimates, as well as a quantifiable description of the difficulty of logging.

The main application of the information is in stumpage evaluation. Some of the information collected has secondary uses in ecological classification, silviculture, and protection.

All stands harvested are timber cruised within 5 years of harvest unless special exemption is granted for some extraordinary cause. Typically, stands are cruised 1 - 2 years before harvesting.

Several variations of the procedure exist, involving fixed and variable plots, plot size differences, intensity of plot establishment, random and systematic plot location, as well as a number of other sampling variations. By far the most common method is the establishment of prism plots on a systematic grid pattern, most typically with strips and plots 200 m apart. Data collected include tree species, size, stems per hectare, distribution, age, growth, crown class, and pathological indicators.

Pest Information

Under the current system, a variety of pest information is collected. Strip notes are used for timber typing and terrain description and, in special cases, for recording pest incidence. Bark beetle infestations are classified by type, intensity, and timing, using a broad code. Blowdown, white pine blister rust, and fire damage data may be collected in a similar manner along the strips, under the current system. These data are primarily collected to aid in timber typing and valuation for harvesting implications.

Pathological indicators on individual trees include the presence and stem location of conk, scar, fork or crook, stem mistletoe, rotten branch, and dead or broken top. In addition, damage codes for each tree may be noted for bark beetle, white pine blister rust, fire damage, and uprooting. These are used as statistical indicators of stem decay, and decay reductions are made in the volume calculation based on their presence. No attempt is made to identify any particular pest other than those specifically listed above.

There is no provision made for specifying the need for pest treatments or prescriptions, although there is a space for the cruiser to comment on quality, logging chance, or anything else he feels warrants a comment.

Opportunities for Improvement

The timber cruise could provide more detailed information on pest occurrences, and supplement the pre-harvest silvicultural prescription (PHSP) process. Cruising has the advantage of greater intensity of ground coverage, thereby increasing the chance that important localized pest problems will be detected. As with the PHSP, a pest field guide would be an asset. Cruisers could be alerted to watch for, and record, incidences of specific problems flagged in the PHSP. If further detail is warranted, specialty surveys could be superimposed on the cruise grid.

Because in 1985 the appraisal system was expected to change, making much of the data collected on the back of the cruise card obsolete, it is possible to revise the card so that more silviculture and protection data could be noted. For example, on the front of the form, columns could be added to record the presence of root rot, Warren's root collar weevil, western gall rust, stalactiform rust, animal damage, and "other," for each tree in the sample or the plot as a whole. This should be designed to match the method and codes chosen for the PHSP.

Where tomentosus root rot is suspected but cannot be confirmed by the presence of obvious signs or symptoms, borings could be made on a main root of one or more of the sample trees to search for symptoms. Even if the species of rot cannot be determined, the presence of a problem would be noted and the district or regional specialists could be alerted to make appropriate subsequent inspections. Trees with and without pest incidence could be used as sample trees to help build an impact data base.

There should be as much compatibility as possible between the PHSP and the timber cruise in pest incidence recording methods and codes.

2.2 Classification

The forest classification system includes information on species, age, height, crown closure, site classes, stand structure, stand stocking, density, and history. Environmentally sensitive areas, inoperable areas, unproductive forest land, and non-forest land are also noted.

Field surveys include ground calls and observations, as well as data from other Ministry branches. Information from silvicultural surveys is used to update inventory or disturbed areas.

Disturbances caused by insects and disease are classified and recorded by timing, mortality, degree of infestation or infection, and specific pest. Subjective levels of incidence used are light, moderate, heavy, and past occurrence. A numerical code is used to identify the pest.

Stratification procedures use aerial photographs to outline homogeneous units. The smallest type is generally no less than 1 cm^2, regardless of map scale. Plots are established at infrequent scattered ground calls. Size and type of plot vary with the type of stand, as does the amount of information collected. Plots can be established in juvenile or mature stands, but because they are only used to confirm data from aerial techniques, they are infrequently and selectively placed. Not all units are sampled.

The form used is basically similar to the timber cruise. Pathological indicators are noted, as are pests, using the inventory codes. Additional pest data can be noted. In both cases data are collected to describe the stand in the terms noted above.

Air classification, in addition to describing the stand attributes, records incidence of bark beetles and defoliating insects where they can be observed from the air.

Disturbances, including pest occurrence and incidence data, are recorded on silviculture history records and mylars.

Opportunities for Improvement

Although inventory data are not generally detailed or comprehensive enough for operational purposes, they are used for planning, and therefore, pest information is important.

The pest codes used in the inventory system should be modified to match the pest codes developed for the other surveys discussed to make the various systems compatible. The inventory list of pests should also be reviewed to ensure all significant pests are included, such as the needle diseases and terminal weevils.

2.3 Sampling

Forest sampling is designed to determine the volumes and growth for the various forest inventory types. A multiphase system is used that includes photo and ground samples.

Photo samples are used in conjunction with ground samples as a means of acquiring sufficient data economically. The ground samples provide a thorough description of the plot, including description of the area and data on the stand; stocking description and position; site and soils descriptions; data on disturbances including that by pests; sample tree information; and pathological and quality remarks.

The method used for ground samples is essentially the same as that for forest classification. Although specific valuation data are not collected, some of the same data are collected to describe the site.

Opportunities for Improvement

A uniform pest code is needed here. Data collection on the plot is very thorough but could be improved if provision to record ecological classification and alternate hosts was made.

2.4 Growth and Yield

Permanent growth and yield samples are established in both managed and natural stands at various ages to gather data on site capability and productivity, and to construct yield tables.

Sample plots are subsamples of the forest sampling procedure and much of the data and methodology are the same for cruise plots and forest sample plots. However, the growth and yield plots are permanently marked to facilitate remeasurements. Plots are remeasured periodically at 5 - 10 year intervals, including plots damaged by pests, natural agents, or man, as long as half of the initial trees remain alive. A detailed description of the damage is required.

The field form includes data on pathological indicators, as with cruising and forest samples, and data on rusts and conks coded in the same manner as pathological indicators (i.e., by occurrence and location on the tree). Additional data gathered are tree mortality and in-growth. All stumps are recorded and stems are mapped on all plots.

Opportunities for Improvement

A uniform pest damage code is needed.

2.5 Decay

Some of the forest sampling ground plots established in mature and overmature stands are assessed for decay and waste by felling and bucking trees and making detailed measurements. The presence and location of the recognized pathological indicators (conks, blind conks, scars, fork or crook, trunk mistletoe, large rotten branch, dead or broken top, other abnormalities) are recorded, as are the amount of decay, the type of organism causing the decay, and the entry point.

Equations for waste and decay reduction factors are developed by tree species and zones. These factors are used for all official Ministry timber volume calculations.

3. SILVICULTURAL SURVEYS

3.1 Pre-Harvest

Site-specific field data are used to develop forest management prescriptions. The survey is intended to be done in the 3rd year of the 5 year development plan, that is, 3 years before logging, or, in emergencies where delays cannot be avoided, at the time a cutting permit is initiated.

Plans, maps, records, and inventories are used to partially complete the initial prescription and to focus attention on any specific field data requirements.

Aerial photographs are used to stratify each site into ecological associations. A survey design is then proposed that traverses all ecosystem units. Field data are collected for each ecosystem association.

The survey form includes information on tenure, site condition, soil, vegetation, protection (wildfire and pest management), and non-timber values. Initial prescriptions with secondary options are then completed in the field, based on both field data and preliminary information collected before field inspection. A final prescription by treatment unit is made in the office, taking all the field data into account.

This system is intended to provide a thorough, ecosystem-based evaluation of every cutblock proposed for harvesting in the province, without excessive data collection.

Pest Information

The system specifically includes pest management concerns which are of importance to the current stand and have implication for subsequent reforestation. These include defoliators, bark beetles, root rot, and dwarf mistletoe, which are coded into five classes by percentage of stand affected. Mistletoe is further coded into three classes by percentage of infections on an individual tree basis. The data form allows comments about the damaging agents. Pest treatment needs, timing of treatments, and constraints imposed by pest occurrence can be specified.

Opportunities for Improvement

The pre-harvest silviculture prescription requires individuals highly trained in silviculture, dendrology, entomology and pathology, soils, and ecological classification. For pest evaluation, a field reference is needed, similar to material provided for the B.C. Forest Service Ecological Classification Program.

Such a field pest handbook should include information on each serious pest problem by region and preferably ecological zones and subzones. Suggested information for each pest includes a description (pictures or drawings for recognition), list of hosts, alternate hosts for rusts, symptoms and signs, damage, habits and habitat, method of identifying presence, control methods, and standards for control initiation.

A pest field reference would significantly aid the effectiveness of surveys dealing with pest problems. Development of this reference should be a priority, to ensure that pest information is considered in the silvicultural prescriptions.

A framework for specifying pest treatment requirements assumes that the examiner will be knowledgeable. A pest handbook should help prevent oversights in data collection and should reduce the need for Ministry, regional, or Canadian Forestry Service (CFS) pest specialists to visit every site where a problem is found.

The list of pests specified on the data form (FS 711) should include other pests such as Warrens collar weevil, western gall rust, and stalactiform blister rust. These might be detectable in the mature stand, and will affect site treatment and stocking needs. Some provision should be made for other unexpected pests. including animal damage. For stem rusts, it would be helpful to record incidence of alternate hosts, as well as degree of infection. A list of alternate hosts and pertinent codes should be developed. Similarly, to assist in pest impact evaluation, it would be desirable to use the Sample Trees-Overstory and Understory sections to include both samples of infected trees and samples of healthy trees. The Advance Regeneration section could include the cause of unacceptability if pest-related. A code format should be feasible.

3.2 Site Preparation Guide

This guide was designed to assist in the evaluation of treatment decisions, and was completed along with the final harvesting inspection report. Recommendations for various types of site treatments were made by the Forest Officer.

The form FS 117 was generally used (but not always) where slash-burning was an option. If burning was expected, the Hazard and Risk rating was used; if not, the Range, Silviculture and Mechanical Treatment Impact sections were completed. In either case, the final outcome was a recommended treatment.

Pest information was limited to a comment and a "yes" or "no" answer as to whether insects or diseases were present in the residuals or slash. If "yes", treatment method was requested.

Opportunities for Improvement

The form could be altered to consider specific pests such as dwarf mistletoe, root rot, root collar weevils, rusts, and galls, rather than just pests in general.

In addition to the "yes" and "no" responses elicited in the silvicultural assessment, there should be an option to indicate the need for further data or surveys.

3.3 Planting Prescription

After site treatment, a form (FS 739) is completed to develop a planting prescription, and to ensure that all site factors affecting the survival and growth of planted trees have been considered on each treatment unit in the block. A map accompanies the report. The form is updated if delays occur before planting. Site factors, access and recommendation, prescription, project planning, and stock allocation concerns are addressed in the form.

No provision is made for any pest influence.

Opportunities for Improvement

Pest information to be considered should include known and potential pest incidence. Such data could influence which species to plant, the degree of screefing necessary, spacing of seedlings, and expected survival.

3.4 Planting Quality

After planting, plots for checking the spacing and quality of the trees planted are established as soon as possible and cover all areas planted. Planting spot selection, screefing, planting hole, tree placement, firmness, position of crown or stems, and root placement are all evaluated. Control of planting quality is strict, and payment for work is contingent upon maintaining a high standard.

No other information is collected.

Opportunities for Improvement

Planting is a crucial, high-production function. This survey should not be complicated with more data collection. On burned sites, planters, contractors, and checkers for the Ministry or the licensee should be on the alert for black army cutworm, and procedures should be set up for instant response where a problem is spotted. With a separate monitoring or predicting system for black army cutworm, interference with the planting process should be avoided unless problems are found.

The current practice of noting stock condition on arrival at the field site should also be continued. In addition to gray mold or flushing, any pests or poor conditions should be noted.

3.5 Survival

Survival surveys may be done periodically but are usually scheduled the second year after planting to determine the effectiveness of the planting operation. They are not used to determine stocking, but to measure the effects of various biological factors. The survival surveys are intended as samples only. Approximately 30% of all projects are sampled, some will only have a walkthrough. The surveys may be done by staked plots or lines. Survival and growth are measured on one to two plots per hectare or staked lines, distributed throughout the stratified units. Condition of the tree is noted in general terms and there is space for remarks.

No pest data are sought, and no attempt is made to explain tree mortality or condition.

Opportunities for Improvement

Some attempt should be made to determine the cause of seedling mortality and estimate future losses so that preventative or control measures can be prescribed. This survey could provide the first opportunity to do so.

It might be desirable to present results as a percentage of mortality by cause, and percentages of stems at risk by cause, as well as totals. This could be done without change by merely writing a pest code in the appropriate tree condition column.

The presence and condition of alternate hosts and whether these show signs of infection could be recorded.

3.6 Stocking

All regenerated stands require a stocking survey 3 - 5 years after denudation. Prestratified units are sampled at an intensity of one to two plots per hectare, usually on a grid pattern. Ecological classification, survey objectives, acceptable tree characteristics, and survey parameters are addressed in the procedure.

Observations recorded include height growth, stocking, plantable spots per hectare, potentially preparable area, and difficulty of planting. Free-growing stems per hectare are also calculated when a free-growing survey is done.

Acceptable and unacceptable tree characteristics are specified, and observations are made separately for various layers such as planted or natural seedlings.

Recommendations, based on these results and the stocking standards, are either to plant, juvenile space, treat the site, do a brushing and weeding, resurvey later, or leave alone. Results are entered in the silviculture history records.

No pest information is collected or noted unless the surveyor volunteers a comment alongside the plot data.

Opportunities for Improvement

All stands are subject to the PHSP, timber cruising, a stocking survey, and then a free-growing survey.

These surveys, the common basis for observations in the rotation, are complementary and build on each other, particularly for ecological classification and general silviculture. Pest concerns are addressed to a lesser degree but not systematically.

Pest coding, layer recording method, and alternate host incidence and condition should also be developed and used for the stocking survey. Information could be specified for various pests using the vegetation layer strata for recording. This might aid in evaluation where growth is reduced by a pest, but mortality does not occur.

This method could provide a spatial description of pest incidence as well as an estimate of the number of infected trees, and the severity of infection.

3.7 Free-Growing

All stands are subject to a free-growing survey at approximately five to 10 years after denudation. The same procedures are used as those for the stocking survey. However, the standards for individual trees are set using free-growing standards, as outlined in section 4.35 of the Silviculture Manual.

Opportunities for Improvement

The pest codes needed for stocking and other surveys are also needed for the survey. This survey provides the last look at the stand from a silviculture perspective, unless further stand treatment is prescribed.

3.8 Regeneration Performance

A regeneration performance assessment is intended to provide average performance data (height growth) at about the 5 - 10 year stage of a young stand, and a general assessment of the health of the stand. Information related to ecological classification can be used to illustrate effects of stock types, natural vs planted, and site treatments.

Condition and damage information were collected by noting the type of problem and the specific cause, for example, D1 = Dense, A = Armillaria. Codes for approximately 36 specific problems were used. The level of damage was noted as: no damage, no previous damage, and recovered.

Tree species, origin, category, height, and height growth were tallied. Provision was made for recording advance regeneration if it was acceptable in form, vigour, condition, growth, disease and damage, spacing, and height. There was no mechanism for recording pests on unacceptable advanced regeneration or on residuals.

Tree conditions and damage were described and summarized by code to calculate the proportion of the stand affected.

Opportunities for Improvement

This survey provided the most complete pest management data collection of all the silvicultural surveys. Unfortunately, it is not carried out on all stands and is only done at one time.

Pest impact data could be collected here by sampling infected trees. The pest and damage code used here should include degree of infestation or damage.

Factors that may affect future stocking could be as important to collect as the actual current stocking data. Therefore, pest data should be collected on all plots. It might be simpler to use two separate cards, one for stocking and one for pest assessment.

3.9 Pre-Stand Tending

Surveys of young stands are done to identify and rank stand treatment opportunities. Surveys vary with regions, districts, and objectives. The field plot data include species, size, and distribution, and comments regarding insects, disease, and defects. Unacceptable trees are tallied, but no cause is recorded.

The prescription form summarizes the area identification, access, area description, and stand description; states the objective; and recommends a treatment. The stand description includes stocking data and comments on damaging agents.

The information collected includes damaging agents of concern, and the incidence and condition of any alternate hosts can be described.

3.10 Post-Spacing

These surveys are done to assess the performance of personnel in relation to objectives and specifications for a spacing operation. Strips and plots are established to sample the area. Data on species, size, stocking, unsatisfactory conditions, and any infractions are recorded. The number of crop trees per hectare by diameter class is calculated. The survey includes provision for pest damage.

3.11 Tree Seed

Potential seed production stands are examined, monitored, and evaluated for potential cone crops generally during the course of other field trips. Information is gathered on location, ecological classification, site, soils, vegetation, topography, stand description, tree phenotype, and cone prevalence. Evidence of insect or disease damage is looked for, but only on the cone crop.

These surveys are generally too irregular both in time and location to be of any practical value for pest evaluation for young stands.

3.12 Lodgepole Pine Ground Cones

Ground cone surveys are done to estimate the number, distribution, and viability of pine cones left on site after the logging of pine stands. Site treatment prescription is dependent on the results.

Prestratified units, representative transect lines, and plots are used. Typically a grid pattern is used, with 1.26 m radius plots spaced at 20 m intervals along strips 100 m apart. Information is collected on cone quantity and quality in relation to satisfactory seedbed. Results are tabulated and usually mapped directly at a suitable scale. No other information is collected. The intense ground coverage achieved by this grid pattern could make this survey ideal for some pests such as root rot.

The areas surveyed are not burned and consequently black army cutworm infestation is unlikely. However, its presence, if found, could easily be recorded. Root collar weevils, much more likely to be present, could be spotted at the base of pine stumps and mapped. Any root rot or root collar weevil could affect the timing, type and degree of treatment. Alternate host vegetation and/or pest incidence could be recorded if the information is not already available from the PHSP and/or the cruise. As well, any incidence of dwarf mistletoe on advanced regeneration could be noted.

A standardized pest coding system compatible with other surveys could be used to record pest data.

3.13 Seedbed

This survey is done to determine the amount of satisfactory seedbed available after treatment for either natural regeneration or planting, and to determine payment for the work done.

Strips are run through representative units, and 1.26 m radius plots are established in the same manner as for the Ground Cone Survey. The amount of satisfactory seedbed is recorded per plot, from which plantable area or plantable spots per hectare can be calculated. No other information is collected.

Approximately the same opportunities exist here as for the Ground Cone Surveys. The opportunity to decide on the type of site treatment is, of course, lost by doing the assessment after the fact. However, observations for subsequent management options could still be worthwhile.

4. GENERAL PEST SURVEYS

4.1 Remote Sensing

Satellite imagery is continually improving and will no doubt become very useful in forest pest management. However, as of 1978, pest detection from LANDSAT was not sufficiently accurate to be of assistance in mapping or pest assessment (Harris et al. 1978).

4.2 Aerial

Groups of dead or distressed trees may be spotted from the air. Bark beetles, defoliation, and root rot infection centres may be mapped this way. It should be possible to detect pest problems in plantations or young stands from the air, and schedule follow-up ground surveys. Each Forest District could make good use of the many flights that take place over their young stands.

Sketch mapping and aerial photography are used both by the Forest Insect and Disease Survey (FIDS) of the Canadian Forestry Service and the B.C. Ministry of Forests and Lands. Defoliated, dead, dying or discoloured trees can be observed. Extensive aerial surveys may be conducted for pests such as the spruce, pine, and Douglas-fir bark beetles, dwarf mistletoe, and budworms (Harris and Dawson 1979).

During the last few years, various forest districts have used 1:10 000 colour photographs to assess and reclassify backlog areas. The technique proved useful for outlining areas where subsequent information or treatment was needed. Pest detection could be incorporated into ground checks of the photo-based strata.

The USDA Forest Service, Northern Region, Forest Insect and Disease Management, routinely monitors all U.S. federal lands from the air, covering forests in North and South Dakota, Montana, and Idaho. The procedure and guidelines used are described by Tunnock (1978). Timing of aerial observation was crucial, but an extensive number of pests could be covered. All symptoms of insect and disease damage were recorded, and defoliated stands were mapped and classified by degree of damage. Areas with damage that could be identified from the air were ground checked. A number system was used to identify the pests on the maps produced, and a colour code was used to indicate the degree of damage.

As noted in section 5.9, the New Zealand Forest Service used annual aerial surveys to identify dothistroma needle blight.

4.3 Canadian Forestry Service

The Forest Insect and Disease Survey of the Canadian Forestry Service (CFS) nationally detects pest outbreaks, forecasts their development, determines their extent, appraises the damage caused to forest stands, determines control requirements, and communicates the information to the forest agencies and the public. Data are collected systematically by field staff using prescribed methods, and recorded in a standard procedure to ensure national uniformity (Clark and Richardson 1974).

Annual sampling is conducted, and permanent plots scattered throughout the province are examined. In addition, operational staff in industry and the Ministry of Forest and Lands help monitor pest populations, and provide advice for areas of concern. Annual reports on the pest population of the province are also produced.

The CFS organization, a research and monitoring agency, provides support for operational agencies. For example, Bloomberg et al. (1980) developed several root disease survey methods, one of which was adopted by the Ministry for operational use.

Any site-specific survey is generally a "walkthrough" by a highly trained pest technician. Dr. Van Sickle suggested (pers. commun., 1986) that CFS/FIDS methods were not directly applicable to site-specific and comprehensive survey procedures needed for young forest stands. Consequently, these were not reviewed. Nevertheless, CFS methods should be reviewed in the development of a standardized pest coding system.

4.4 Industry

A telephone enquiry was carried out to determine if the industry in British Columbia has developed or used any other forms of relevant surveys. Companies contacted included: Balco-Kamloops; Canfor-Prince George; Evans-Lillooet; B.C. Forest Products-Mackenzie, Crofton; CIP-Victoria; MacMillan Bloedel-Nanaimo; West Fraser Mills-Quesnel; Northwood-Prince George; Westar-Vanderhoof; Lakeland-Prince George; Weldwood-Quesnel; Western Forest Products-Port McNeill; Weyerhaeuser-Kamloops; and Crestbrook Forest Products-Cranbrook. Generally the companies relied on the CFS and Ministry expertise and methods.

CIP had a permanent system of computer-based record keeping for each parcel of land under its management. Information gathered included general description, site description, forest cover description, and site and stand conditions. Pest information such as root rot, browsing, and mistletoe was also included. Areas were assigned priority codes based on severity of problems noted. A high severity code would result in a more detailed study or survey being done.

The CIP system had no formal data-gathering systems for pests that could assist in the development of pest survey methods. CIP relies on observations made by staff who are aware that any pest conditions observed in a stand during work activities should be reported.

Weldwood of Canada Ltd. in Quesnel developed a regeneration survey system for Tree Farm 5 before the current Ministry stocking survey system was devised. The data included site conditions and history, seedling species, height, height increment, type, age, stocking, soils, stand condition, competition and indicator species, and treatment prescription. Provision was made for collecting data on insect and pathological damage, including pest identification and resulting stem condition. Specific pests assessed were gall aphids, white pine leader weevil, European pine shoot moth, northern pitch twig moth, and western gall rust, and space was provided for other pests. A code of 1 to 10 was used to describe the percentage of occurrence. The concept, including the specific pests and codes, should be applied to Ministry survey procedures.

5. PEST-SPECIFIC SURVEYS

5.1 Root Disease

The Ministry Protection Manual, Section 6, Volume II, outlined the distribution, biological features, general indication and damage, identification, and general control methods for the major root diseases of British Columbia.

Root disease surveys are required, along with other pre-harvesting surveys, and presumably other silvicultural surveys. The intent is to identify potential problems early so that subsequent surveys can focus on the problem. Pest-specific surveys are only justifiable where the disease is substantial and control measures are feasible.

A modified version of the intersection length method of surveying for root disease (Bloomberg et al. 1980) was adopted for use in root disease inventories on a regional basis. Sketch mapping procedures were felt to be a necessary complement for operational site-specific situations (Beale and Wood 1985). The procedure subsequently was described and adopted into the Ministry Protection Manual. It has also been used in research projects for data collection, for example, a study by Merler (1984) of root disease of spruce in central British Columbia.

Wallis and Lee (1984) reported that large-scale aerial photography could be used to detect root disease centres in mature to over-mature coastal Douglas-fir stands.

At the time of writing this report, it was uncertain whether the survey methods developed for coastal southern stands would be applicable to northern interior forests.

5.2 Dwarf Mistletoe

Dwarf mistletoe signs and symptoms are easily seen on most infected trees. Aerial reconnaissance, roadside surveys, and plot surveys have been used for detection and evaluation of severity of attack. Surveys generally use a rating system for recording the incidence and intensity of dwarf mistletoe.

Aerial photography is not recommended for the inventory of dwarf mistletoe infections, but may be useful in the assessment of the intensity of attack on individual stands (Leduc 1985). Overflights and roadside surveys are used to provide a general estimate of the amount of infection (Vyse 1981).

The Ministry has adopted the following method for roadside surveys. Based on subjective observer opinion, stands are rated for incidence from a slowly moving vehicle. Ratings per timber type are recorded on maps of a suitable scale. This type of survey was first used by Hawksworth in 1956 (Dooling 1978).

Individual trees are generally rated by a six-point system as described by Hawksworth (1977), or modifications of this such as the nine-point system, or the three-point system used on juvenile trees. Essentially the crown is divided into thirds and points given based on severity of infection in each third. The total point count gives the tree rating. These rating methods can be incorporated into any plot type or configuration. The Ministry adopted all these methods as official procedure, as described in Volume II of the Protection Manual.

There is a need for collecting ecological classification and mistletoe data during both pre-harvesting and regeneration surveys. Vyse (1981) recommended that timber cruise methods be amended to ensure that maps of infection are part of Cutting Permit applications. It is also important to collect stand structure data and topographic data as spread of dwarf mistletoe varies with factors related to stand structure and is influenced by topographic barriers (Alfaro et al. 1985).

5.3 Western Spruce Budworm

The Canadian Forestry Service annually monitors western spruce budworm on Douglas-fir in British Columbia, and predicts outbreaks and trends of populations. Seventy three permanent sample stations were located in British Columbia, mostly in the southern interior (Harris et al. 1985). If this pest were a major concern for young northern stands, as suggested by Cariboo Forest Region Staff, then consideration should be given by the CFS/FIDS to establish permanent sample plots in the northern areas.

The methods of surveying and population sampling are similar to those for spruce budworm. Information can be collected as part of cruise strips and plots, and defoliation can be mapped from air observations (Harris et al. 1985).

5.4 Warren's Root Collar Weevil

Cerezke (1970) developed a sequential sampling system for determining the level of root collar weevil attack in a particular stand. Herring (1981) suggested that this survey could be used where weevil symptoms are noted in the course of normal plantation assessments. The method involved examining up to 100 individual trees for weevil presence, while ensuring that the entire stand is represented. A grid pattern was suggested. Stratified silviculture surveys could easily be amended to include collection of weevil data in this manner.

Richards[1] recommended detection surveys for root collar weevil before harvesting so that appropriate treatments could be carried out. He recommended that all surveys in lodgepole pine should check for root collar weevil. Herring (1981) recommended that damage assessment be carried out as part of the regeneration performance assessment procedure, so that the resulting data could be considered in establishing stocking standards, and in determining whether treatment is required or is possible.

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[1] Richards, R. 1982. Silvicultural control of Warren's root collar weevil. B.C. Min. For. Lands, Prince George East For. Distr. File Rep.

5.5 Leader Weevils

The only sampling technique found for lodgepole pine leader weevil was that used by Maher (1979). Data collected from trees in fixed area plots included information on current attack, previous attack as evidenced by dead leader stubs, year of attack, type of resulting deformity, tree density, dbh, height, and leader growth.

Robertson and Dewey (1983) used a similar approach in their research survey for determining western pine shoot borer incidence, impact, and stand hazard in western Montana and northern Idaho. However, for each plantation they also collected data on elevation, physiography, slope, aspect, soil characteristics, geologic parent material, habitat types, method of planting, and site preparation technique.

Cozens (1983) described a whitepine weevil survey method. A continuous strip survey on a grid pattern with 10 m wide transects was used in conjunction with standard regeneration plots. Plots were used to define species composition and stocking levels, and strips were used to define attack levels for each tree (no attack, current attack, 1 - year-old attack, and 2 - year and older attack). Other stand and site parameters possibly related to weevil attack were collected for each plantation (elevation, aspect, slope, percentage other species, average spruce leader length, percentage overstory, percentage brush, height of brush, weevil distribution-local patch, homogeneous, other insect/disease problems). Ecological classification associations were, interestingly enough, not noted, although Heppner and Wood (1984) observed that risk or hazard zones for weevil on the coast were related closely to the ecological classification.

Cozens (1983) also stressed the need for a comprehensive survey before silvicultural prescriptions are made, and recommended that a weevil hazard index for the Prince George TSA be developed. However, while photographic techniques might become more important for detection and assessment of leader weevils, they will not be able to replace a ground survey (Cozens 1983).

As well, Cozens (1983) noted that plantations in the Prince George area generally do not become susceptible to attack by Pissodes strobi until they have been established for 10 years. He recommended that spruce plantations over 10 years old be surveyed to determine the existence and extent of the weevil.

Further silvicultural surveys, including the free-growing survey at stand ages of 15 to 20 years, would be adequate for dealing with the potential major leader weevil problem in spruce plantations in northern British Columbia.

5.6 Black Army Cutworm

Several authors as reported by Shore[2] proposed five methods for sampling black army cutworm populations and risk-rating areas before planting. Methods included adult sampling using pheromone traps, egg sampling, larval sampling, pupal sampling and sampling herbaceous growth. Herbaceous growth sampling in the spring before planting was felt to provide a useful measure of risk. A "Herbaceous Index" rating system based on plot data was proposed that used species by value of preference, degree of defoliation and quantity of plants present to calculate a risk rating for potential black army cutworm damage to newly planted trees. The value of the index as a standard for decision making would improve over time as more "herbaceous indices" were correlated to the actual extent of plantation damage.

Blackstock (1985) further developed and field tested the vegetation index concept. He found that cutworm damage was dependent on site factors such as aspect, slope, and preferred vegetation. Site and vegetation diagnosis before planting was described as a useful risk and damage prediction tool. Sampling methods were adaptations of the B.C. Ministry of Forests and Lands survival and stocking surveys. Plots were established on a systematic basis, that is, at every 50 m along pre-determined strips, and data were collected on vegetation and shrub damage and ecological site factors. Timing of survey and quick response to results were crucial in dealing with this pest.

Aerial and general surveys will not be useful for black army cutworm infestations. This pest requires a separate detection and evaluation survey because of the nature and timing of infestation and damage. Surveys must take place in the extremely short period of time between removal of snow cover and planting unless adequate prediction techniques are developed. Previous surveys may assist by collecting data on type, amount, and quality of preferred herbaceous vegetation.

5.7 Aphids and Midges

A major detection survey for balsam woolly aphid carried out in British Columbia by the Ministry in the late 1960's is described by Harris (1968). Survey methods included aerial observation of dying trees and crown damage, and ground observations. Since only geographic distribution was of interest, trees were examined just for the presence or absence of the aphid on the bole or in the branches.

Surveys for a pine woolly aphid in Kenya used damage classes. These classes (tolerable, critical, intolerable) were based on the amount of needle stunting, the numbers of aphids per centimetre of shoot length, and the percentages of infected twigs (Mailu et al. 1978). Sequential sampling procedures were used to gather data.

No survey procedures for any other aphids or midges were found.

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[2]Shore, T. 1983. Problem analysis: sampling the black army cutworm for potential hazard to regeneration. Summary of meeting October 6, 1983, at Pac. For. Cent., Victoria, B.C.

5.8 Stem Rusts and Cankers

No survey procedures were found in the literature dealing with these pests. However, cruise and silvicultural surveys could collect suitable data.

5.9 Foliage Diseases

New Zealand has a major problem with dothistroma needle blight on radiata pine. Kershaw et al. (1982) described the problem, assessment, and control procedures. Annual surveys were undertaken in July and August before the annual spray programs.

Disease levels on the whole stand were estimated from aerial surveys, and ground surveys were used to estimate disease levels on individual trees. A rating system scoring the percentage of green crown infested was used. Scoring was done in 5% steps and based on foliage colour. All stands where dothistroma was identified were surveyed annually.

Ground surveys were progressive in intensity. Levels of infection below 15% received a walkthrough and a general estimate only, while heavier infections were sampled along transects, with 100-200 trees being sampled. Aerial surveys were done by low-level flying with either fixed-wing aircraft or helicopter. Stands rated from the air at more than 15% infected were also ground checked. Spraying was not considered until infection reached 25%.

No other survey procedures were found in the literature.

5.10 Bark Beetles

Procedures have been developed by the Protection Branch for assessing spruce, mountain pine, and Douglas-fir bark beetle infestations. Methods included aerial sketch mapping of symptoms, ground probe lines, and timber cruising. Infested areas were probed to determine degree of infestation.

Probe lines consist of strips along which tree tallies, incidence of beetle-attacked trees, and timing of attack are noted. Systematic larvae counts are also made to estimate population buildup potentials. Field notes are made, which, along with the counts, allow mapping of infested timber by degree and timing of infestation.

Where results indicate a problem, harvesting is usually prescribed. Timber cruises are then designed to include beetle data. Infested areas and volumes can be determined from data collected.

Bark beetles are usually not a concern in young stands, so this process is generally only relevant in determining areas that may soon need to be reforested.

6. CONCLUSIONS

In 1985, approximately 25 general forest and silviculture surveys were used by the Ministry of Forests and Lands and the forest industry. Most of these included little information on pests and pest damage of young trees. However by 1987, several of these surveys--including pre-harvest prescription, stocking, and free-growing assessments--were modified to include appropriate pest data.

Surveys for an individual stand covered a maximum time from 5 years before harvesting to up to 15 years after harvesting. With rotation ages in excess of 100 years in the interior of British Columbia, stands should be monitored for a longer period of time for pest management purposes.

In most of these surveys, sampling usually included only representative healthy trees. Samples of infected trees could help determine impact, assist the development of risk and hazard ratings, and facilitate development of standards for control and treatment.

Two other shortcomings appeared common in most surveys. Tree mortality was noted, at best, but cause was seldom recorded. Usually only data on acceptable advance regeneration were collected, but none on the amount or cause of unacceptable regeneration. Information on cause of death and cause of rejection could have important implications for later stand development and potential future losses.

Although some pest surveys have been adopted by the Ministry--for example, for root diseases, dwarf mistletoe, and bark beetles--these have been designed for specific pest problems rather than for a determination of overall stand condition or health. A general pest survey for immature and young forest stands could be developed, to follow the free-growing survey. The format should incorporate data collected for any pest. Stand, site, and pest data collected in previous surveys should be considered. Potential formats for such a survey include modified versions of the pre-harvest silviculture prescription, the stocking survey and regeneration performance assessments, the free-growing survey, and the pre-stand tending survey. A format combining these surveys would be desirable.

Ideally, all stands should be subject to at least one general pest survey after the free-growing stage is reached. If done too early, pest problems may not yet be evident; if left too long, treatment and control may become more difficult. Consequently the survey should be done approximately 3 - 8 years after the free-growing survey, unless previous field observations suggest an earlier evaluation.

Throughout the review of existing surveys, the suggestion was made to develop a standardized pest code that could be used in any field survey. Both the CFS and Ministry branches should be consulted to develop a coding system compatible to all needs. This may require a multi-level code that can be used in various degrees of detail for different purposes.

The coding system should first identify the pest. All significant pests should be considered and provision made for additions to the system. Second, the occurrence and incidence of the pest must be categorized. Degrees of infestation per tree may be expressed differently from pest to pest depending on the nature of the problem. This could be expressed as estimates of numbers of the pest present, numbers of trees affected, amount of tree or part of tree affected, or the intensity of pest on the tree or part of the tree. The degree and seriousness of tree damage should also be categorized. Estimates of pest and current infestation, as well as potential for recovery, must be considered. In some cases, the degree of damage and of infestation may correlate closely enough that separate codes are not warranted.

Recording of stand parameters (species, stocking, age height, crown closure, growth), the ecological site classification (aspect, slope, soil, nutrients, moisture, vegetation), and pest data (as discussed but also including alternate host and preferred vegetation data) would assist in the development or refinement of risk and hazard ratings to predict future potential damage for each pest.

Standards for treatment and control options are essential and should relate to the code system for each pest in a manner similar to that currently in place for mistletoe. A standardized pest code format would help in formulating population threshold levels for various degrees of control treatments. As more experience and data are available, both the standards and the coding options should be refined. A standardized pest code system should be described on a separate Ministry form for field reference.

The Ministry Inventory Manual, sections 9.3 and 9.4, contains insect and disease information that could form the basis for a pest field reference or handbook. The manual includes brief information on distribution, hosts, adults, eggs, larvae, pupae, symptoms, and damage, as well as colour illustrations for the most important insect problems. Diseases are described in a similar manner.

Considerable additional information is available for a field reference, such as the Ministry Protection Manual, Volume 2, and CFS reports, brochures, and survey methods. This information should be condensed and incorporated into a format suitable for field use, and based on regional or ecological occurrences.

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