ROOT DISEASE SURVEY METHODS
PHASE II

A PROPOSED MULTISTAGE SURVEY METHODOLOGY FOR DEFINING ROOT DISEASE LOSSES IN TIMBER SUPPLY AREAS

by

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(The contents of this report may not be cited in whole or part without the written approval of the Director, Protection Branch, Ministry of Forests, 31 Bastion Square, Victoria, British Columbia V8W 3E7)

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
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February 27, 1986

File: 1609

Dr. J. Muir, Pathologist
B.C. Ministry of Forests
Protection Branch
1450 Government Street
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Dear Sir:

Re: Phase II of Our Proposal to Review Root Disease Survey Methods

I have attached two copies of our report entitled, "A Proposed Multistage Survey Methodology for Defining Root Disease Losses in Timber Supply Areas (TSA)."

Our report outlines the development of a new multistage sampling methodology and describes in detail each stage in the implementation of the survey design. We believe this design to be the best practical approach to identifying root disease losses in a large forested area.

We have continued our examination of literature and our interviews with key personnel in the Ministry of Forests (MOF) and the Canadian Forestry Service (CFS). In the development process, we have investigated the availability of maps, aerial photography and forest cover data required for the planning and implementation of our proposed multistage methodology.

The methodology developed and reported in Phase II will be applied to a TSA in order to test the procedure (Phase III). We have selected the Okanagan TSA for a test of our proposed methodology. Our Phase III report of our Proposal to Review Root Disease Survey Methods will detail the test results on the Okanagan TSA.

We would like to express our thanks to Mr. B. Hall, Mr. I. Spandli and Mr. M. Blyth of the MOF Inventory Branch, for their consultation as well as Ms. E. Hamilton of the Research Branch.

In addition, we further thank Dr. W. Bloomberg, Dr. J. Lee, and Dr. D. Morrison of the Canadian Forestry Service for their helpful comments.

Dr. G. Wallis, Forest Pathologist, and Mr. E. Vaughan, R.P.F., along with myself have jointly developed the proposed survey methodology and contributed in the writing of the Phase II report.

We trust our report meets with your satisfaction.

Yours very truly,

T.M. THOMSON & ASSOCIATES LTD.

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Enc.

EXECUTIVE SUMMARY

Current root disease survey methodology is not suitable for estimating timber volume losses over a large geographical unit such as a Timber Supply Area (TSA). A new multistage sampling methodology is proposed in order to provide a means of estimating timber volume losses caused by root diseases for a TSA. A flowchart describes the step-by-step procedure for the proposed sampling methodology.

The proposed method features the use of the MoF's comprehensive Data Bank and computer mapping facilities in combination with field sampling using large-scale aerial photography and ground truthing surveys.

Biogeoclimatic subzone classification mapping is the base information used in the proposed procedure. At each successive stage in the procedure, land areas or forest types are labelled as "risk" or "non-risk." Final sampling is completed only on a portion of the "risk" forest types. Volume loss estimates are based on the sampling of "risk" forest types and projected over broader land areas.

TABLE OF CONTENTS

		Page
COVER LETTER		ii
EXECUTIVE SUMMARY		iv
1	INTRODUCTION	1
2	DEVELOPMENT OF METHODOLOGY	2
3	FLOWCHART OF MULTISTAGE METHODOLOGY	4
4	EXPLANATION OF MULTISTAGE SAMPLING METHODOLOGY	5
5	DISCUSSION AND EVALUATION	9
6	REFERENCES	11

FIGURES

1	FLOWCHART OF MULTISTAGE SAMPLING METHODOLOGY	13

1 INTRODUCTION

The Phase I report (PM-PB-63) on root disease survey methods, entitled "Critical Review and Assessment," determined that current root disease survey technology worked well for small areas with discrete infection centres, but was inadequate for assessing extensive timbered regions such as B.C. interior TSAs.

The MoF must set allowable harvest limits for TSAs throughout B.C. A forecast of timber volume yield is necessary in order to set harvesting limits.

An integral part of the compilations involved in forecasting timber volume yield is the recognition of timber losses expected over the harvesting period. Future timber losses, for example, like those resulting from the impact of fire, insects, and disease must be included in the compilation. Broad estimates are normally used for estimating timber volume losses.

The Canadian Forestry Service (CFS) has estimated annual losses to root diseases in British Columbia to total 3 000 000m^3, mostly due to reduced productivity of infested sites. Root diseases are particularly damaging to young second-growth forests.

A more accurate estimation of timber losses can be made by developing timber volume loss factors for each type of loss (such as root disease). There is a necessity to develop new survey methodology in order to satisfy the need for a more accurate estimation of root disease-related losses. New methodology could be used to provide a quantitative estimate of benefit derived from root disease control treatments.

This report will describe the development of a new, multistage root disease sampling methodology for operational application to large areas of timber.

The development of the proposed methodology required further consultation with MoF and CFS personnel. In addition, literature on multistage sampling used by other agencies had to be reviewed.

A flowchart is provided which outlines the multistage sampling process. Each stage of the multistage sampling process is described in detail following the flowchart.

2 DEVELOPMENT OF METHODOLOGY

The development of the proposed multistage methodology required consultation with interested people from other agencies, review of background literature, and review of the source, extent and types of information available from the MoF.

The following agencies and personnel were consulted in our investigation of a multistage sample design:

- B.C. Ministry of Forests:
  - Inventory Branch

    Mr. B. Hall - Supervisor, CAM Data Input
    Mr. I. Spandli - Forester, Statistics Officer
    Mr. M. Blyth - Manager, Computer-Assisted Mapping

  - Research Branch

    Ms. E. Hamilton - Research Ecologist

  - Air Photo Supply Services
- Canadian Forestry Service, Pacific Forestry Centre
  - Dr. W. Bloomberg - Research Scientist
  - Dr. J. Lee - Research Scientist
  - Dr. D. Morrison - Research Scientist

During the consultation meetings, the concept of a multistage methodology was reviewed along with an assessment of data limitations. A general strategy for the methodology was planned.

Multistage sampling methodology has been used by agencies in other parts of Canada as well as the United States of America. This development of a multistage methodology included a review of available literature relating to multistage sampling methods used by other agencies. The references section of this report lists the literature reviewed in the development of this proposed multistage methodology.

The success of any survey methodology depends on the accuracy and reliability of the data upon which the survey method is based. Therefore, an extensive review of available sources of information (data) was conducted. The primary source of information

is the MoF Data Bank. Various computer data summaries, forest cover maps, biogeoclimatic subzone maps, and aerial photography were assessed for their suitability in our proposed multistage methodology.

3 FLOWCHART OF MULTISTAGE METHODOLOGY

A flowchart (Figure 1) charts the stages in defining root disease losses occurring within large areas of forested land such as a TSA. The accompanying explanation provides the materials and information (with sources) necessary at each stage in the flowchart.

4 EXPLANATION OF MULTISTAGE SAMPLING METHODOLOGY

A stage-by-stage explanation of the procedure outlined in Figure 1 follows.

STAGE 1

Obtain from the MoF map supply (MS) office, a key map for the TSA selected for root disease surveys. The TSA key map will be at a scale of 1:250 000. The MoF Data Bank can supply area and volume statistics for TSAs. The MoF Data Bank contains comprehensive forest data and statistical records for all of British Columbia. In addition to statistical information, a wide variety of other map and aerial photograph data is available from the Data Bank.

The TSA key map delineates Supply Block (SB) and region-compartment boundaries. The TSA key map will not show Public Sustained Yield Unit (PSYU) boundaries; these may be required, and if so, can be transferred from a PSYU key map. The PSYU was the administrative unit of area in use before the development of the TSA and SB area. The reason for still requiring PSYU boundaries is that not all information that is available from the Data Bank is cross-referenced to TSA and SB areas.

STAGE 2

Obtain from the appropriate MoF region office a biogeoclimatic subzone (BGCS) key map for the TSA along with descriptions of the individual biogeoclimatic units. Superimpose the subzone lines from the BGCS key map onto the TSA key map. Identify and label the BGCS as either "risk" or "non-risk."

A "risk" is a subzone that indicates a presence of forest types which are susceptible to root disease infection. For example, those BGCSs in the Okanagan TSA that indicate a major presence of dry and wet belt Douglas-fir and wet belt western redcedar and western hemlock species associations. These associations are known to be particularly susceptible to root disease infection.

A "non-risk" BGCS is a subzone where there is not a major presence of forest types which are susceptible to root disease infection.

STAGE 3

Identify on the TSA key map those SBs that are entirely or partially within "risk" BGCSs and those SBs which are entirely within "non-risk" BGCSs.

This stage will stratify those SBs which require further assessment from those SBs which can be eliminated from survey sampling.

STAGE 4

On the TSA key map, identify the regions/compartments within each "risk" SB that are in "risk" or "non-risk" BGCSs.

All regions/compartments within an SB are "risk" areas when the SB is entirely within a "risk" BGCS. But in those "risk" stratified SBs where the SB is only partially within a "risk" BGCS, it will be possible to further stratify the regions/compartments within that SB into "risk" and "non-risk" areas. Those regions/compartments which are stratified as entirely "non-risk" can be eliminated from survey sampling.

STAGE 5

Obtain the forest cover maps (FCM) from MoF MS, 1:20 000 scale, for the SBs stratified as "risk." Identify the "risk" region/compartment boundaries on these maps. Obtain the projected map attribute lists and area listing (HEC Report) from the MoF MS for each 1:20 000 scale map. Where the 1:20 000 scale maps are not available, obtain the older 20 or 40 chains/inch FCMs. The older FCM maps are not accompanied by projected map attribute lists and HEC Reports, so it will be necessary to obtain PSYU region/compartment data summaries for the older maps.

STAGE 6

Delineate on the FCM within "risk" regions and compartments the "susceptible" species/site types from the "non-susceptible" species/site types.

Species susceptibility ratings for each root disease are available from related literature and/or from the Canadian Forestry Service, Pacific Forestry Centre. Forest stands that have undergone several partial harvest cuttings (selective logging) are particularly prone to heavy losses if root disease is present in the area. Forest stand disturbance information (such as logging), may be determined from FCMs, MoF Data Bank, or aerial photography.

An example of a "susceptible" species/site type in the Okanagan TSA would be forest types that are immature according to MoF Forest Inventory standards where Douglas-fir, western redcedar, or western hemlock are the first major species (20% by volume) of the forest type.

The stratification of "non-susceptible" species/site types at this stage eliminates the need for survey sampling of these areas.

STAGE 7

Calculate the percentage area of occupancy of the "susceptible" species/site types to the total area of the region/compartment. Stratify and label those "susceptible" species/site types which have greater than 10% of total occupancy, from those with less than or equal to 10% of total occupancy. Those "susceptible" species/site types which have less than or equal to 10% of total occupancy can now be eliminated from survey sampling. The 10% level has been chosen as a realistic sample intensity level. This has not been tested in the field, but will require verification by field testing, and possible adjustment before full-scale operations.

Actual areas in hectares can be obtained from either the PSYU region/compartment data summaries or the 1:20 000 scale HEC reports (map polygon area lists). This information is obtainable from either the MoF MS office or the MoF Inventory Branch.

STAGE 8

Within a region/compartment, identify and select a portion of the "susceptible" species/site types having greater than 10% of total occupancy. Some of the selected types will be sampled in field operations. The sample selected should represent 5% of the area stratified as a greater-than-10% "susceptible" type. The sample should represent a cross-section of species/site types from the "risk" compartments selected. The 5% level has been chosen as a realistic sample intensity level. This has not been tested in the field, but will require verification by field testing, and possible adjustment before full-scale operations.

At this point it is possible to determine the number of large-scale aerial photographs required for adequate sampling of the selected "susceptible" species/site types.

STAGE 9

Obtain new large-scale aerial photography for the species/site type areas to be sampled in the field. Our investigation has determined that aerial photography should be at a scale of 1:10 000 to 1:15 000, and preferably be true color.

The implementation of this proposed multistage sampling methodology requires good timing at this stage. The pre-field planning stages 1-8 of this proposed methodology must be completed in advance of the best period for flying and taking aerial photographs, which is May to September. The field sampling stage is also best completed during May to September. Indeed, the large-scale

photography should be obtained in June or July in order to allow the aerial photo assessment and ground sampling to proceed during the recommended period.

STAGE 10

Use the new or recent large-scale aerial photography to stratify the selected "susceptible" species/site types into four classes. The four classes are:

1. Absent - those "susceptible" species/site types in which root disease is not detected.

2. Light - those "susceptible" species/site types in which detected root disease encompasses less than 2% of the total area of the type.

3. Medium - those "susceptible" species/site types in which detected root disease encompasses between 2-15% of the total area of the type.

4. Heavy - those "susceptible" species/site types in which detected root disease encompasses greater than 15% of the total area of the type.

The four classes of "susceptible" species/site types are now grouped into absent and light classes and medium and heavy classes. The absent and light classes are excluded from further sampling, while the medium and heavy classes are selected for ground field sampling.

STAGE 11

At this stage, a field assessment of selected types must be undertaken. An appropriate ground survey procedure should be used such as the MoF Length Intersection Survey Method (described in PM-PB-63) or a line-plot method such as that which is currently under investigation by other agencies.

STAGE 12

The area loss information collected during the field sampling stage of this proposed procedure will be compiled using computer technology. Area loss data will be converted to loss factor percentages for reducing annual increments at specified periods. Managers will then be able to adjust volume over age (yield) curves for the susceptible species/site types of the TSA.

The forecasted yield for a TSA will then represent a more realistic measure of the volume loss associated with root disease.

5 DISCUSSION AND EVALUATION

A number of pathogens are responsible for root disease infections in interior British Columbia forests, but two, *Phellinus weirii* and *Armillaria ostoyae* are responsible for major losses.

Areas of damage from root diseases extend throughout a broad range of forest types, but are known to be major in specific species/site types and ecological zones (e.g., dry and wet belt Douglas-fir, and wet belt western redcedar and western hemlock mixtures). In many areas, management practices have aggravated the problems, particularly selective logging. Also, young Douglas-fir planted in areas previously occupied by decadent western redcedar and western hemlock is being heavily damaged by *Armillaria* infection.

Because of the nature of the extensive and widely scattered occurrence of root disease damage, use of current methodology is prohibitive, both cost- and time-wise, for defining root disease losses in large tracts of timber. Multistage sampling methodology utilizing the MoF Data Bank, ecological subzoning, forest cover species/site type mapping, large-scale aerial photography and known root disease risk rating supported by minimal ground surveys, should provide the procedure necessary to estimate timber volume losses due to root disease.

It has not been possible, within the resources of this contract, to verify the procedures proposed. Extensive testing will be required to define survey levels relative to disease and site variation and level of accuracy required. For example, as mentioned earlier, the selected sampling levels established in Stages 7 and 8 have not been verified through field testing. Field testing may show that these levels will require adjustment in order to establish a suitable level of accuracy.

Before this methodology can be applied in field operations, personnel must be thoroughly trained in root disease damage identification. This will include the ability to interpret root disease damaged areas on aerial photographs and on ground surveys.

The skill in identifying infections by individual pathogens will also be necessary.

The information available from the MoF Data Bank records and computer mapping facilities will be essential. The ability to use this information in the multistage sampling process will be an important requirement.

The assistance of MoF and CFS staff expertise in determining training schedules will be required.

There are data limitations associated with the application of this methodology. These limitations will hinder the application of the proposed methodology. For example, the

MoF has not completed its computer-assisted mapping program for all TSAs. In addition, the forest cover mapping available from the MoF, in some cases, is based on 20-year-old inventory information. Much of the forest cover attribute data available in metric measure has been directly converted from imperial measure without further field or ground substantiation.

Multistage sampling techniques used in the USA are similar to the proposed methodology outlined herein. The sampling conducted in the USA National Forests applied a more intensive aerial and ground survey. It is felt that the level of survey intensity in this report's methodology is realistic with the scope of assessment required and the accuracy of the data that is available.

The scope of this contract does not allow a verification of the procedures proposed. It is recommended that a test of the proposed methodology be conducted in its entirety on a selected TSA. Survey intensity (percentage sample), with respect to disease and forest site variations, may require modification following a "test run" of the proposed methodology.

The proposed Phase III report (PM-PB-65) applies the methodology proposed in this report to the Okanagan TSA.

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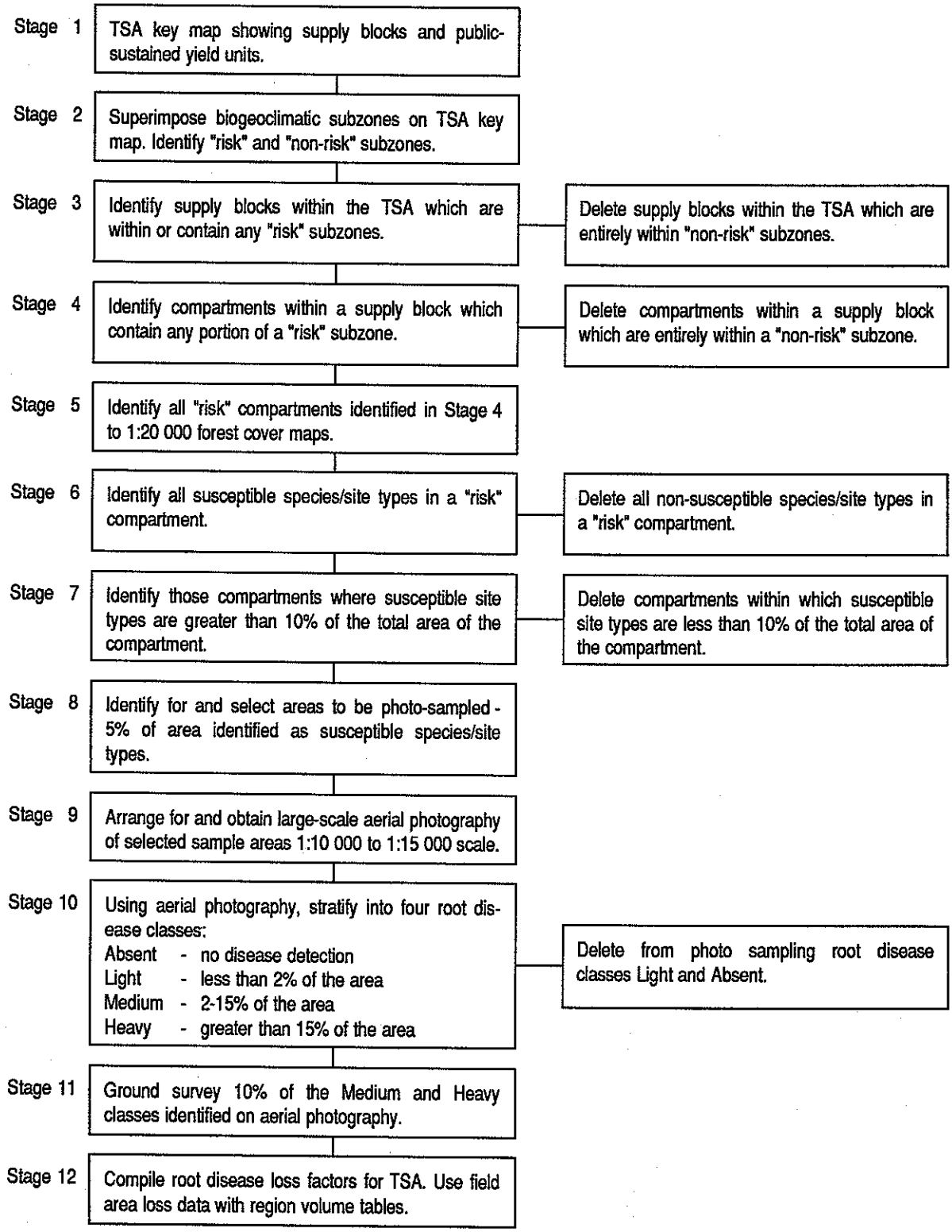
FIGURE 1 FLOWCHART OF MULTISTAGE SAMPLING METHODOLOGY