

APPENDIX II

TERMS OF REFERENCE FOR THE TASK FORCE ON A
FOREST PEST MANAGEMENT INFORMATION SYSTEM FOR B.C.

INTRODUCTION

A pest management organization can be perceived as providing two basic service functions to resource managers. The first provides information on each important host-pest interaction to facilitate understanding and decision making. The second is a range of acceptable prevention and control options from which resource managers can choose to regulate pest populations and their damage commensurate with resource production objectives.

Since 1980, when the nucleus of a pest management organization was established in the B.C. Ministry of Forests, one prime need has been the development of a comprehensive Pest Management Information System (PMIS) which adequately serves resource managers. Existing information systems do not meet the complex requirements of today's resource managers nor is data being collected which will satisfy managerial needs ten years hence.

The Forest Insect and Disease Survey (FIDS) of the Canadian Forestry Service has been the major collector of pest information in B.C. since 1948. This data is generally at an overview level except for specific problems or studies. There is a great need for a pest management information system which links with the inventory; planning and yield calculation; history record; and geographic systems of the BCFS.

(To help provide a focus, the attached Figure 1 gives a simplistic view of how a Pest MIS would fit into the Ministry of Forests' information systems, and Figure 2 presents a crude schematic of a functional pest management information program. Both will provide some insight into the linkages [real or potential] with other programs and systems.)

THE TASK FORCE

A Task Force has been formed to conceive and develop the framework of a pest management information system for B.C. and to provide an implementation plan. The members have been chosen on the basis of their background and with the agreement of their employer that considerable time and dedication will be expected. The group is composed of the following:

Bob Sutton (Chairman), B.C. Ministry of Forests, Protection Branch,
Victoria.

Terry Shore, Canadian Forestry Service, Forest Insect and Disease Survey,
Victoria.

Paul Wood, B.C. Ministry of Forests, Pest Management, Vancouver.

Russ Cozens, B.C. Ministry of Forests, Pest Management, Prince George.

TERMS OF REFERENCE

The Task Force is given considerable leeway in its mission as there are few existing systems known in forestry. However, any information systems in use in forestry or agriculture will need to be assessed. The following terms of reference are provided for guidance:

1. The overall objective of the Task force is to develop the framework and procedures necessary to implement and operate a pest management data collection, storage, and retrieval system which will significantly improve the accessibility, quantity, and quality of information available to resource managers, thereby enabling them to more precisely determine pest impacts and to decide on the actions required to improve the productivity of forest and rangelands in the Province.
2. The system must be developed to efficiently handle the major and economically important forest insects and diseases. The information system framework should meet this criteria if it is developed to handle the following types of pests:
 - (a) Bark beetles
 - (b) Defoliators
 - (c) Mistletoes
 - (d) Root rots
 - (e) Terminal weevils

3. The determination of the degree of responsiveness of the system to the decision-making needs at different levels of management is part of the Task Force's assignment.
4. The system must be capable of being interfaced with the other basic information systems, eg., the Forest Inventory, TSA planning system, History Record systems, and Canadian Forestry Service pest data systems.
5. The system must be capable of being expanded to accomodate each phase of the forest cycle: seed and cone; nursery; establishment and young immature; advanced immature; mature; and overmature phases.
6. The Task Force must consider the following items before determining the practical limits of an initial and basic information system:
 - occurrence status of major pests
 - anticipated pest behaviour
 - predicted impact on resources if a pest is uncontrolled
 - appropriate pest treatments or management strategies, their costs, and predicted impact on resources
 - basic information to establish priorities and funding levels for pest-related prevention, control, and research activities
 - improving the accuracy of pest loss estimates and their impact, and thus the reliability of resource use output goals, such as the AAC in each Timber Supply Area
 - monitoring pest management activities and treatments, resource management practices, their costs and effectiveness
 - information requests by the public or legislature
7. The Ministry of Forests will be the agency responsible for operation and maintenance of the system. The degree of integration with the Canadian Forestry Service and other agencies or institutions is to be investigated by the Task Force.
8. The Task Force is expected to consult with and seek advice from a wide range of resource managers and pest specialists in government, industry and education.
9. The Task Force, in order to achieve its objectives, must meet or be otherwise functioning at least five days each month, starting no later than September, 1984.
10. The Task Force is to submit its report to the Chief Forester by April 1, 1985.

Fig. 1 - Ministry of Forests Management Information System
(Partial and Simplistic)

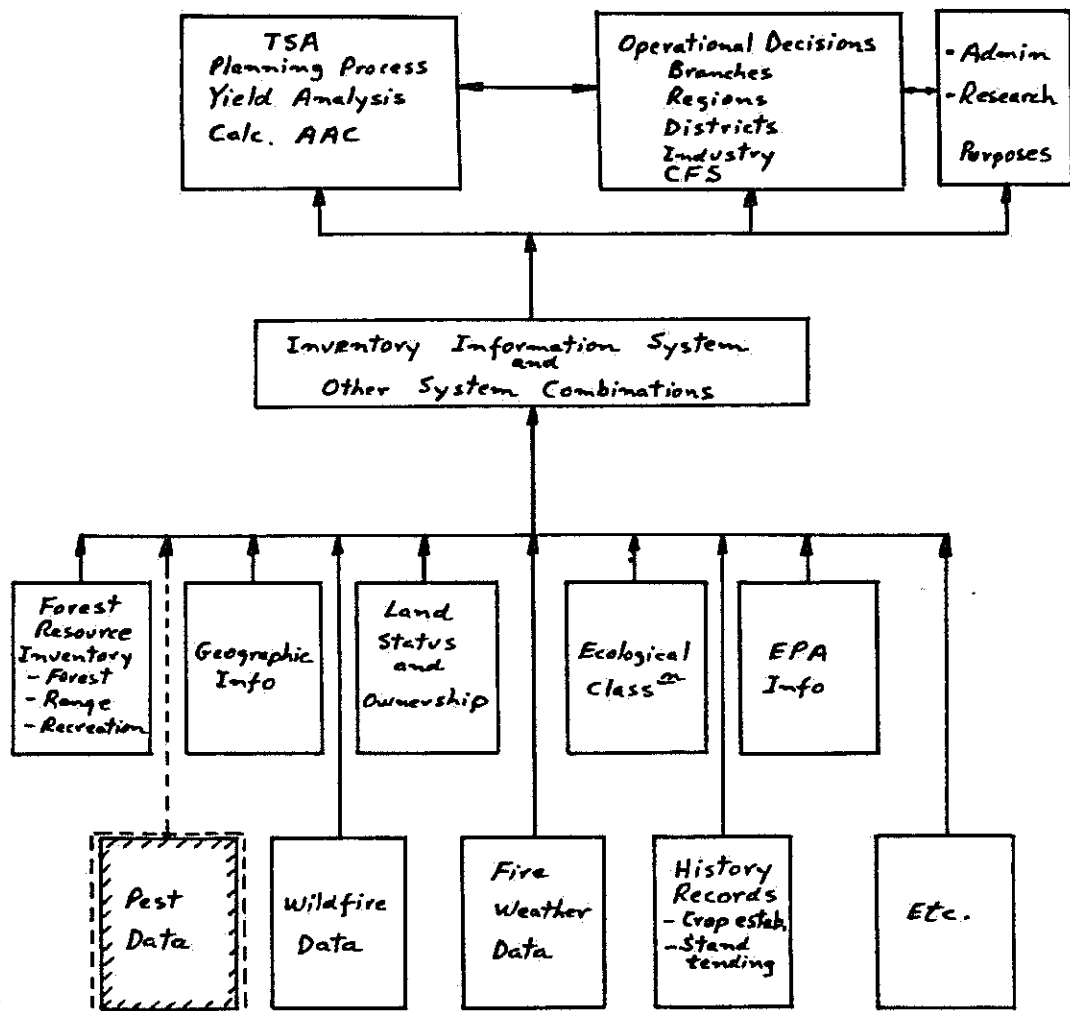
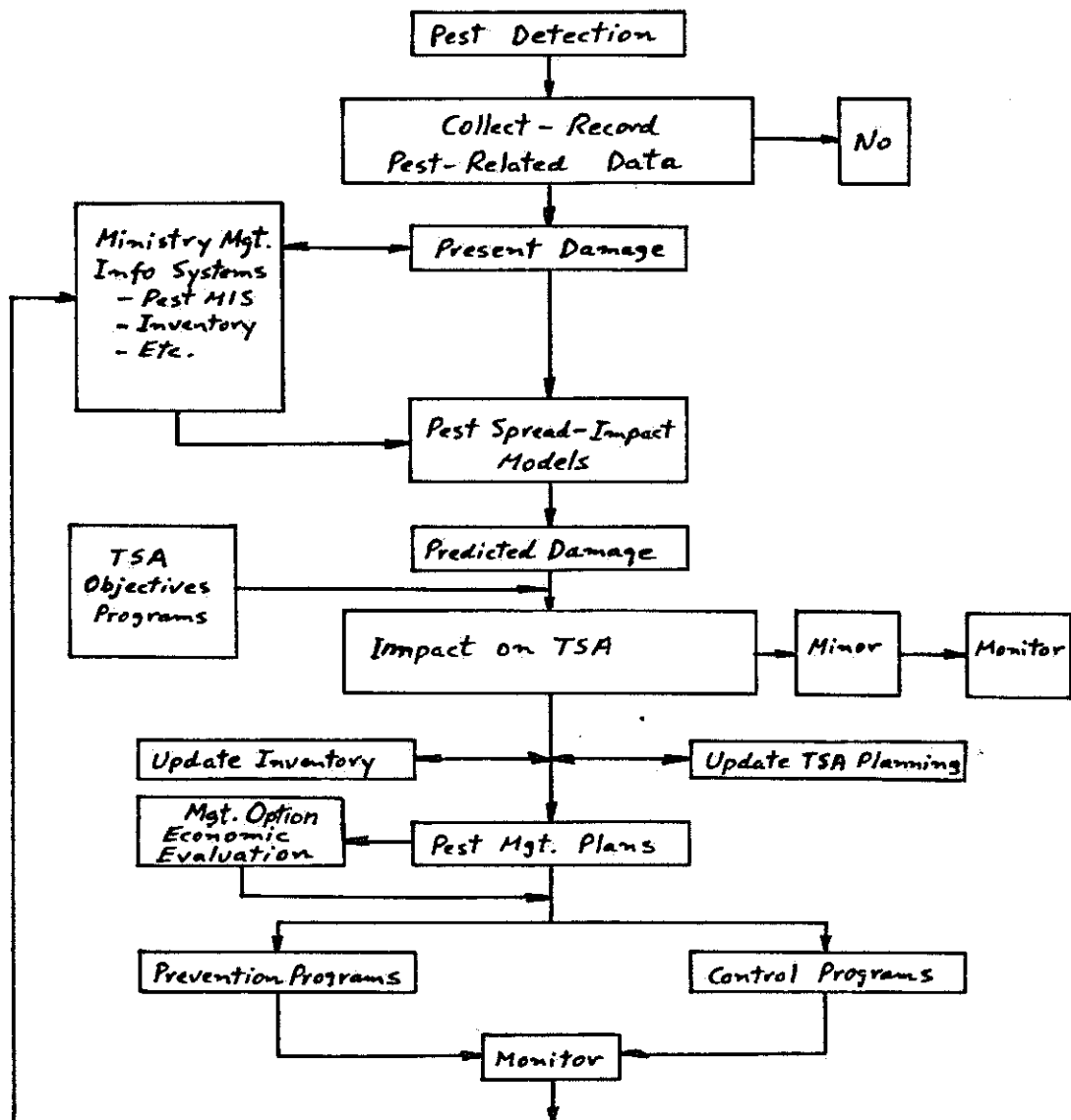


Fig. 2 - Outline of a Functional Pest Mgt. Program



APPENDIX III

TASK FORCE FINDINGS

The Task Force takes full responsibility for any errors contained in these reports of the results of consultations with the various specialist groups.

1. Literature Search and Discussions with Other Agencies

To avoid "reinventing the wheel," one of the first efforts of the Task Force was to determine if any other groups in North America, or elsewhere, had designed a pest management information system that could be adapted for B.C. Forest Service purposes.

Several approaches were used. Most regional offices, and the national headquarters, of the U.S. Department of Agriculture, Forest Service (USDA-FS) were contacted by telephone. Canadian federal systems were examined through contacts and literature available at the Pacific Forest Research Centre. Canadian provincial systems were checked through Task Force knowledge and discussion with the forest entomologist of the Ontario Ministry of Natural Resources. Agriculture Professors at the University of B.C. were consulted. Relevant literature known to members of the Task Force, and their colleagues, were studied. For a list of references consulted refer to Chapter VII. Finally, the international computer literature search facility, DIALOG, was used to search through thousands of entries in journals of forestry, agriculture, biology, or related disciplines and other citations. Noteworthy details from these contacts and searches are listed in Appendix IV.

The conclusion of the Task Force following this search was that there were no available systems which would suit the purposes of forest pest management in B.C. The agricultural systems were inappropriate because they do not require the complexities of inventory information and long term tracking of pest activities inherent to a forest crop. The most promising system was the

Integrated Pest Impact Assessment System (IPIAS) being developed by the USDA-FS Methods Application Group (MAG) at Fort Collins, Colorado. Their system is conceptually similar to that required for B.C. but there are some fundamental differences in the structures and systems of forestry in B.C. and the U.S.A. which require different paths of development. The major difference is that the USDA-FS inventory database on System 2000 is not a geodatabase. The MAG therefore has the initial task of transferring the inventory information onto a geographic information system. The B.C. Forest Service on the other hand is well on the way to having all of its forest inventory on a polygon-based geodata system. Another major difference is that IPIAS utilizes a stand growth model, PROGNOSIS, to which several pest models can be linked (e.g. mountain pine beetle, Douglas-fir tussock moth, western spruce budworm) to provide pest impact information. There is no comparable system in B.C.

Finally, the Task Force concluded that a custom-made Pest Management Information System is required to fully integrate with existing B.C. Forest Service systems, responsibilities and organizational structures. In particular, the superior capabilities and uniqueness of the B.C. Forest Service inventory systems were major factors in reaching this conclusion.

2. Analysis of Questionnaires

As outlined in the previous section, a questionnaire was sent to a carefully selected list of 130 specialists, managers, and practitioners in order to obtain a balanced opinion on what a Pest Management Information System should include. Seventy-eight of the 130 questionnaires (60%) were returned, some of which were collaborative efforts among several respondents. A list of respondents is contained in Appendix I.

It was originally intended to analyze the questionnaires by dividing the respondents into agency, branch, and/or administrative level subgroups. However, it became obvious on reading the responses that there was

considerable consensus regardless of the agency or position of the respondent. Therefore the questionnaires were summarized by reviewing all the responses to each question and extracting the original ideas. These are summarized in Appendix I.

3. Data Requirements of Pest Specialists

The management of pests necessitates the collection of data to determine their location, damage resulting from their activity, and projected impact upon the forest resource. Four types of data are required and these are:

- (1) Location of pest damage
- (2) Pest identification
- (3) Stand/pest data
- (4) Trend data

(1) Location of Pest Damage

a) Always required:

- date of survey
- forest region
- forest district
- geographic description
- tenure
- type of survey
- TSA
- in or out of the net operable land base

b) and if available:

- map sheet number
- inventory polygon number

c) but if b) is not available then:

- map region number
- map compartment
- UTM grid

d) if applicable:

- History Record System "opening" number

All data are applicable to the five pest types being considered by the Task Force (e.g. bark beetles, defoliators, leader weevils, root rots, and dwarf mistletoe) except "opening number" is not applicable to the bark beetles.

(2) Pest Identification

Data required to assist in the identification of the pest:

- host species
- age class
- crown class
- type of damage - location on tree
 - description
- pest identification
- agency and person supplying the pest identification

(3) Stand/Pest Data

a) Stand data required - may be able to obtain some of these from maps, etc. (i.e. not necessarily all items require ground surveys)

i) Essential

- timber type - inventory label
- site history - past surveys
 - past treatments
 - attribute listing
- access - current type
 - difficulty

ii) Desirable

- biogeoclimatic zone - subzone, variant, and ecosystem association
- aspect
- slope - actual
 - position on slope
- elevation
- diameter distribution by species*
- species mix - stems per hectare or %

iii) Optional

- height class by species
- soil type**

* not required for leader weevils

** only occasionally required for root rots

b) Pest Data Required - defines current status

Note: all data is considered essential for all pests (except where noted by footnotes)

- area infested (hectares) - total and by intensity class
- number of damage centres (patches)^a
- average size of damage centres^a
- type of distribution of centres or patch location^b
- infestation intensity - % of stems affected by category
- stand susceptibility (hazard)^c
- % of non-susceptible species
- age of infestation^d

-
- a - does not apply to defoliators
 - b - does not apply to bark beetles or defoliators
 - c - does not apply to mistletoes
 - d - does not apply to root rots or mistletoes

Note: such things as infestation intensity and susceptibility must be developed on a pest-specific basis

(4) Trend Data

- to be collected on a pest-specific basis as per Manual instructions

The above list includes only those data required for operational decision-making and planning. Data to drive specific pest prognosis models may or may not be included and would therefore be collected as and when required.

Consistency in the quality of the data collection is paramount. The methods of collection must be consistent within and between regions to ensure that any comparisons of parameters are not influenced by misrepresented data. This can be overcome only through the establishment of strict standards, thorough training, and continued monitoring.

4. Inventory Branch Consultations

The geographic information systems of the Planning and Inventory Branch were examined by the Task Force to determine their potential for satisfying three pest management objectives:

- (1) ability to supply information required by Pest Management.
- (2) ability to store information generated by Pest Management to serve Pest Management.
- (3) ability to accept pest-related information from Pest Management that assists Planning and Inventory Branch procedures.

The forest inventory systems in the province are basic to any enhancements in a Pest MIS and accordingly deserve description in some detail.

The systems in Planning and Inventory Branch are undergoing rapid evolution. The branch is currently in the process of building a graphics data file (which electronically stores map information) and also is expanding the forest statistics database. Evolution, however, is not instantaneous. Currently, approximately 40% of the province's forest area has been converted to new graphics files and statistical databases, and the formats for portions of the database are still being worked out. This has been an important consideration for the Task Force. As pest management is highly dependent on inventory information, the changes in Inventory's systems influence the design of "interim" or "final" pest management information systems. It also implies, however, that Pest Management should have an influence on the design of the evolving inventory data files.

The basic units of forest inventory are (1) maps depicting forest cover types and (2) files that list the statistics attributable to each forest cover type. Files are necessary because the statistics are too numerous to fit onto the maps. Files of statistics lend themselves well to computer storage which easily allows statistics to be modified without having to change the maps. Current computer technology can now store and modify maps (graphics files) and their statistics files simultaneously.

The B.C. Forest Service is placing all its forest cover maps into the Interactive Graphics Design System (IGDS). Forest cover types (polygons) and other features on the maps are digitized and stored electronically. There are several features of IGDS that distinguish it from the previous mylar mapping system, as listed in the following:

	<u>Mylars</u>	<u>IGDS</u>
<u>Format:</u>	Mylar storage, paper maps printed from mylar.	Electronic storage, hardcopy (mylar or paper) maps generated on request.
<u>Units:</u>	NTS System Imperial or metric 7 1/2 x 7 1/2 minute map sheet, 1 1/4 x 1 1/4 minute grids	BCGS System Metric 2 000 m x 2 000 m grids
<u>Update Process:</u>	Manual modification of mylars. Statistics recalculated by grid, sent to Inventory Branch for computer entry (GAUS).	Maps updated by Computer Assisted Mapping (CAM) System. Forest Cover Attribute Files simultaneously modified. GAUS update also retained.
<u>Availability:</u>	Updated maps housed in districts, copies sent to regions and branches.	GEOMAP (if implemented) will allow district and region limited uploading and downloading capacity but hardcopy maps only available from Inventory in Victoria.
<u>Practical Level of Resolution:</u>	Polygon: 3 ha	Polygon: 3 ha. "Dot" references are made to polygons less than 3 ha, if finer detail is required.
<u>Special Features:</u>		Color coded hardcopy maps with up to 16 colors, to highlight attributes common to various elements may be available in the future. Polygons numbered on the map. Screen viewing of maps. 64 layers of information storage capacity. Approximately one-half are in current use.

An upgrading of the forest statistics database files is also underway. Several layers of information are maintained in the system. Of basic importance are the Master Attribute Files. These consist of two components: the Forest Cover Attribute Lists containing stand level forest cover information and the History Attribute Lists containing some disturbance and silvicultural treatment information. Each forest cover polygon on a digitized map in IGDS has its forest cover and history attributes listed. In addition, there are files describing inventory regions and compartments, TSA's and their Timber Supply Blocks, Public Sustained Yield Units, Agricultural Land Reserves, ownership categories, and other boundaries.

The Expanded Grid Area Files (EGAF), on the other hand, contain an amalgamation of the abovementioned files (with two exceptions), with some polygons being split by administrative boundaries into resultant elements. The exceptions are that the current EGAF does not contain the Forest Cover Attribute List or History Attribute List information. However, it does contain all basic forest cover information for each resultant element, on both digitized and non-digitized map sheets. The EGAF also houses information in 2 000 m x 2 000 m (400 ha) grids.

The proposed Forest Inventory Planning System (FIPS) files are intended to reformat and expand EGAF to incorporate additional information such as biogeoclimatic codes, elevation, slope, aspect, and gross and net volumes.

(1) Ability to Supply Information Required by Pest Management

Both the EGAF and the Attribute Files provide basic descriptions (except for volume) of forest cover. The only major difference is that the Attribute Files have more detailed information, and include history attributes. If information is requested from EGAF, it can be supplied by map sheet and grid, inventory region and compartment, or other administrative units. Summaries of forest cover data by grid (400 ha) may be of sufficient resolution for large bark beetle or defoliator attacks, especially for areas affected outside of the net operable land base. Similarly, summaries by inventory region and

compartment may have application for some bark beetle or defoliator problems, as compartments are delineated to correspond to drainage boundaries.

For almost all pest management purposes, however, resolution to the polygon or element level is required. At this level of resolution, forest cover information is presently cumbersome to obtain. Information for pest-affected polygons must be manually selected from the list of elements in a grid (or some other unit such as a compartment). This is equally true for digitized or non-digitized map sheets, as the current EGAF files do not list the polygon numbers for digitized map sheets.

It is possible that special programs could be developed to provide reporting by only selected polygons. As the file management system to accompany the proposed FIPS files has not yet been developed, it is a recommendation of this Task Force that this selected polygon reporting capability be included.

Volumes by species for affected elements or polygons is an especially important information requirement for pest management. Current EGAF files do not list volume information. Until recently, volumes have been obtained by matching EGAF information to the appropriate AVL's, or VAC's and then listing them. Recent adoption of Ek-Payendah equations, however, has refined this process by calculating volume on the basis of site index and age.

Although the EGAF does not store volumes directly, any printout of EGAF information can have volumes included by matching volume information from another file. This technicality is not important in itself, except for one aspect - it makes inventory updating for pest deletions awkward. Consequently, it may be necessary for pest management to maintain its own records of depleted polygons in order to avoid "double counting."

As with other attributes, volumes are also somewhat cumbersome to obtain at the selected polygon level of resolution. For example, if a forest region or forest district wishes to obtain the volume of lodgepole pine in an area under attack by mountain pine beetle, one of the following options may be chosen:

- (a) "dot" count the affected areas and multiply by the appropriate AVL or VAC and sum the results, or
- (b) refer to Grid Area-Volume Lists. In these, each grid has listed all its elements, with volume by species. To obtain the lodgepole pine volume in the affected area, one would have to select the listed volume from each affected element and add up the total.

It is debatable which method is more expedient. The current method used in the Cariboo Forest Region for bark beetle assessment is option (a). This option also allows greater resolution by calculating volumes for only the affected portions of polygons or elements.

The need for a special program to provide this reporting capability is apparent.

It is very important for pest management to be able to determine if an individual polygon is included in the net operable land base. Essentially, the net operable land base is a function of three factors:

- (a) Commercial Timber: The net-down phase of a TSA yield analysis sets the criteria for commercial timber. Non-commercial species, most low and some poor sites, Environmental Protection Areas and Environmentally Sensitive Areas are all excluded.
- (b) Hauling Distances: The further a stand is from the mill, the greater is the delivered wood cost, to the break-even point.
- (c) Physical Operability: Accessibility and slope govern the logging chance.

Some districts now have an operability code (In or Out) for each element listed in the Area Files. This ranking is an estimate of physical operability and a "guesstimate" of economically feasible hauling distances. It would, therefore, be possible for some districts to roughly color in maps to depict the net operable land base.

The Planning and Inventory Branch is working on a project which will combine the delivered wood cost, slope, and net-down criteria into a determination of operability for each grid (400 ha) on IGDS. The intention is that this information will soon be available on the proposed FIPS files.

Sometimes there are conflicts regarding the data obtained for immature stands from the Inventory System compared to the same area in Silviculture's History Record System. The History Record System records the stocking of acceptable, well-spaced stems as well as the stocking of all species, from regeneration surveys, survival studies, and regeneration performance assessments. This is also the information that pest management requires for these stands. On the other hand, Inventory records only the actual species composition, from a number of sources, and is less concerned with criteria for acceptable, well-spaced stems.

In the cases where these two information systems supply different information for the same stands, for pest management purposes, the History Record System information is often more appropriate.

(2) Ability to Store Information Generated by Pest Management to Serve Pest Management

The IGDS contains 64 overlays of storage capacity, of which about 32 are in current use. It is assumed that some layer(s) could potentially be used for pest management mapping requirements.

Most operational maps of pest infestations, or of pest management activities, would not be appropriate for recording on IGDS or mylar map sheets. There are three reasons for this.

Firstly, the level of resolution is too detailed for Inventory. Root disease pockets, probe lines for weevils or bark beetles, trap tree locations, pheromone baits, and so on, all require much greater resolution than 3 ha. The possible exceptions are aerial surveys for bark beetles or defoliators.

Secondly, the major purpose of entering pest information on inventory maps would be to update "disturbances." The Inventory Manual defines a "disturbance" as "the result of an event that causes tree mortality or tree removal." Most pest impacts, therefore, cannot be defined as disturbances. Only the mortality causing pests, the bark beetles and some defoliators cause disturbances per se. For example, a 20% spruce weevil infestation in one year does not necessarily mean a 20% change in stand composition.

Thirdly, for multi-years of historical pest occurrence maps, the mylar system is not designed for overlays. The IGDS, however, does have several unused layers of storage capacity which could potentially house at least an "annual overview" of pest occurrences.

Inventory can record disturbances due to insects or diseases on the History Attribute List (HAL). This list has 17 codes for insect species and 4 codes for disease species. Either degree of infestation or degree of disturbance (i.e. "proportion of volume or area disturbed") can be recorded in 10% units (i.e. a one digit column). For each polygon there are two opportunities to record disturbances. So if, for example, the polygon has been logged (a disturbance), then only one position remains for a pest disturbance. The HAL is thus not designed to handle multi-years of historical information and for pest management purposes, is too limited.

Currently the History Attribute List is not in EGAF, which means that area-volume information must be obtained separately from disturbance information. Nevertheless, for the purposes of inventory update, and, therefore, pest management input into the yield analysis process, there is a responsibility for Pest Management to contribute to the History Attribute Files (or some other avenue for inventory update).

(3) Ability to Accept Pest-Related Information From Pest Management that Assists Planning and Inventory Procedures

Inventory Branch is concerned with "disturbances" due to pests. The degree of disturbance is measured as the "proportion of the volume or area disturbed." This can be expressed directly as a percentage of volume or area depletion, or indirectly as a change in stand composition or stocking. Thus, a pest event must meet the above requirements before it can be used to change or update the forest inventory database.

To clarify if they qualify as forest inventory "disturbances," each of the five pest categories considered by this Task Force is briefly discussed:

- (a) Root diseases: Although root diseases do cause tree mortality, the rate of kill over the length of a rotation is so slow that at any one time the proportion of standing dead trees is small. Therefore, at any one time, the affected stand would not likely qualify for an inventory depletion update. Besides, Inventory Branch feels that the many inventory plots in the province have adequately captured these losses, and to further record depletions would be to double count the losses. The significant expansion of root diseases in managed stands is a growth and yield problem and does not qualify for inventory update per se.
- (b) Mistletoes: Mistletoe damage is mostly manifested as incremental losses in stands. Very little mortality occurs at any one time. Inventory Branch also feels that inventory plots have adequately captured these losses. The prevention of mistletoe in young managed stands may enhance the historical productivity of the affected species, but this is a growth and yield problem. Mistletoe also does not qualify for inventory updates.
- (c) Leader weevils: These insects seldom cause mortality. Rather, they reduce the height growth and merchantability of the host species. In effect, they can govern the "acceptability" of the host species in a stand. This is information that Silviculture uses to determine the "acceptable, well-spaced" stocking of a stand, as recorded in the History Record System. Inventory does not necessarily measure the stocking of a stand by the same criteria, but is more interested in total stocking. Leader weevil, therefore, does not qualify for inventory updating, except vicariously through the History Record System.

- (d) Defoliators: Most defoliator attacks, despite looking bad for a few years, manifest almost all of their damage as incremental losses, with some "top kill." These do not qualify for inventory update. It is only the odd patch of mortality, identifiable after the attack has declined, that is acceptable for Inventory update. However, there are exceptions among the defoliators, the Douglas-fir Tussock Moth being one, where that pest can cause considerable mortality.
- (e) Bark beetles: All the major bark beetles do cause mortality and, therefore, qualify for inventory update. However, the host species in an attacked stand is not always depleted 100% and a factoring process is required. Possible exceptions are the Douglas-fir Beetle and, sometimes, the Balsam Bark Beetle. These beetles can manifest damage in small patches, smaller than the mapping resolution of Inventory. Over a period of years, the volume can be significantly depleted in a stand, but in any one year these may not meet the criteria for inventory update.

In summary then, most bark beetles and some defoliators would be the major pests which qualify for inventory update because of the mortality they can cause at the stand level.

There are three methods available to pest management for providing Inventory with updates to their information systems.

(1) Gross Factoring

This option applies a volume reduction factor to the next yield analysis process. The factor is listed under "disturbance" in the History Attribute List of an affected polygon. This option would not change the polygon label, nor any of the other attributes associated with it, nor the maps.

(2) GAUS System (Grid Area Update System)

- (a) This option updates the polygon label and modifies its attributes. Volume reductions, however, are limited to polygon units, as reflected in label changes. For example, an S 841-M stand that loses less than 5% of its volume would maintain the same label. A 6% to 25% depletion would change the label to S 842-M. With a 26% to 75% depletion, the label would become S 84R-M. If more than 75%

of the volume is lost, the label would become NSR. This limitation will not exist in the proposed FIPS files. The GAUS option would not change any graphics (i.e. maps).

(b) The above GAUS option can also be enhanced by adding updated maps of "disturbances" (not simply infestations).

(3) CAM System (Computer Assisted Mapping System)

This option updates both the graphics files and Attribute Files simultaneously (IGDS plus database). The shape and descriptive attributes of polygons can be modified, or new ones created. Obviously, this procedure is applicable only for map sheets that have already been digitized onto IGDS.

Until such time as districts and regions have GEOMAP (or equivalent) capabilities, CAM updating must remain a function of Inventory Branch in Victoria, with districts supplying branch with updated mylars and hand written Attribute File information.

For digitized maps, there is the full choice of gross factoring (HAL), GAUS update, or CAM update (when available). For non-digitized maps only the GAUS option is available. If the History Attribute Lists are used, they must be matched on separate area-volume lists before the amount of disturbance can be determined. (Note: Area-volume lists do not list polygon numbers, only element numbers within a grid; History Attribute Lists have only polygon numbers, not elements). As bark beetles often infest a stand for more than one year, it is important to know what volume deletions were made the previous year(s) in order to judge the appropriate deletions for the current year. But History Attribute Lists do not store multi-year disturbance history. For this purpose a separate record of pest occurrences and volume depletions would have to be kept.

By GAUS or CAM updating, the polygon label is changed to reflect the disturbance. But again, for multi-year disturbances, a separate record would be required to judge the appropriateness of label changes for the second or subsequent disturbances. Only with the proposed FIPS files will pest management be able to change the volumes of polygons (or elements) directly. Although once again, a separate record of historical disturbances will be required.

Finally, Inventory Branch has expressed that it will accept Pest Management information for updates, but the responsibility for accuracy and precision lies with Pest Management.

The Task Force recommends that special studies be arranged to determine the level of accuracy and precision that has been and can be achieved from current aerial sketch mapping techniques. If additional accuracy and precision are required, then a special study group should be formulated to explore avenues for enhanced detection capability using remote sensing or other techniques. It is possible that this aspect of detection could be shared with Inventory Branch, as there are two separate objectives: infestation information for pest management purposes, and inventory update.

In summary, the B.C. Forest Service's Inventory Systems will eventually be able to provide almost all the geographical information that pest management requires. A major exception is the silvicultural information for those stands on the History Record System.

When IGDS expands by providing GEOMAP or equivalent capabilities to districts and regions, and the proposed FIPS files are available for the entire province, then Pest Management's inventory information requirements will be satisfied to the level of resolution that the system can provide. The Task Force recommends that the entire body of the Master Attribute Lists be incorporated into EGAF (and, therefore, into FIPS) and to extend FIPS file management handling capability to the resolution of specified polygons.

In the meantime, inventory information is somewhat awkward to access. Most information is dependent on IBM generated "look-up" lists at the "grid" or "compartment" level of summation. Disturbance history and some other attributes are not included in EGAF and must be matched separately. Unavailable information such as net operable land base delineation and biogeoclimatic subzone variants are also noted. There is a major concern that both digitized and non-digitized maps are usually 1 to 4 years (occasionally more) out of date.

With regard to storage capacity for pest management generated information, most pest management operational maps are too detailed for the IGDS level of resolution, and are inappropriate for inventory storage. Only mortality disturbances are appropriate for inventory updating. These are caused by most bark beetles and some defoliators. Most pest impacts, however, including impacts from diseases, plantation pests, and some defoliators, do not qualify for inventory updating. History Attribute Lists are insufficient for pest management purposes but provide one avenue for updating volume depletion.

5. Silviculture Branch Consultations

The full title of Silviculture's information system, generally called the "History Record System," is the "History of Crop Establishment and Tending." This system is designed to track forest stand treatments of what and how much was done, where, and at what cost. Surveys and treatments for site preparation, reforestation, stand tending, and site rehabilitation are scheduled and their results and costs recorded. Each record is specific for an "opening," roughly defined as a disturbance due to logging (or other causes), that requires silvicultural assessment and treatment. "Openings" are created and updated in the districts, and the information sent to Silviculture Branch in Victoria where it is loaded onto the computer database.

Hardcopy "opening" records and/or summary reports are produced at the regional offices and mailed to the requesting district. Sometime in 1985, all districts are expected to have complete software packages for their Wang Professional Computers which will enable them to upload reports.

There are approximately 60,000 "opening" records on the system at present.

As in the Inventory Branch consultations, Silviculture's History Record System was examined to determine its potential for satisfying three pest management objectives.

(1) Ability to Supply Information Required by Pest Management

The History Record System (HRS) can provide the basic stand level forest cover information that pest management requires for stands that are in the system, i.e. those areas designated as "openings." Unlike Inventory systems, the HRS highlights the acceptable, well-spaced species components for the crop to be managed. In particular, the stocking levels are determined on the basis of ecologically suitable, well-spaced, commercial species, whereas Inventory records the actual stocking. Consequently, some information important for pest management purposes, is best obtained from the HRS, and not the Inventory system.

History Record "openings" only occur in the net operable land base, whereas Inventory Branch will be able to fully determine whether an individual polygon is in the net operable land base only when the proposed FIPS files have been implemented. This is a very important concern for pest management.

The current turnaround time from the district mailing updated silviculture information to Victoria and its being recorded on the system is approximately 30 days. Once on the system, turnaround time for a district request for a report is only 2 days. Uploading time will be shortened to perhaps a few days when districts have the software capability.

The TSA yield analysis process, in its calculations of long-run sustainable yield (LRSY), must determine the productivity of immature stands in the net operable land base, and for this purpose uses information in the Inventory systems. The History Record System, on the other hand, sometimes has a different interpretation of forest cover information than the Inventory systems. Thus, two information systems often supply different information for the same stand. In managed stands, the History Record System data are often most appropriate for pest management use. However, as the yield analysis process uses Inventory Branch data, pest management on managed stands may not be incorporated into the yield analysis process.

A major recommendation of this Task Force is that Inventory Branch's Attribute Files list both the Silviculture and Inventory interpretations of forest cover for managed stands so that Planning personnel can use the most appropriate data for yield analysis.

(2) Ability to Store Information Generated by Pest Management to Serve Pest Management

In its current format, the History Record System can record a "pathogen" code and a choice of high, medium or low intensity level. Finer resolution of intensity is required for most pests of second growth stands, usually to the nearest 1%.

The HRS is restricted to an "initial" pest occurrence, and a "current" occurrence, this being the most recent observation. The system is not intended to store historical or multi-year pest information nor is it designed to record multiple, simultaneous pest occurrences in an "opening." For example, if an "opening" has both weevils and mistletoe, only one of them can be recorded.

The following categories of stands are normally not captured in the HRS: mature stands not scheduled for harvest, stands outside the net operable land base, and stands in the net operable land base not due for silvicultural assessments or treatments.

Pest management on young stands can be regarded as one form of silvicultural practice. In order to control or prevent damage from pests, pest management prescriptions can include:

- the type of site preparation
- the species to be selected
- the type of stock
- the timing of planting
- the stocking density regime
- the timing of regeneration assessments
- the criteria of acceptability of crop trees
- the timing and type of stand tending operations
- the time and method of harvest
- the type of site rehabilitation

With the exception of timing and method of harvest, the History Record System is specifically designed to accommodate these "silvicultural" or "pest management" activities. There are deficiencies, however, in the codes recognized by the system. For example, there is only one code recognized for pest surveys, one for pest management stand tending operations, and none for pest management site rehabilitation.

It is important to note that, most of the above problems with the HRS could be easily amended. Pathogen intensity levels can be expanded to a two digit percentage level, multi-years of survey information (in Section "C") can be recorded with their pest intensity levels (in Section "I"), and codes for pest surveys and treatments can easily be added. "Openings" can also be created for pest management activities in the net operable land base.

At each district office, files are kept for each "opening" in the district. These files contain maps and more detailed reports. These files could serve as repositories for pest management maps and reports.

(3) Ability to Accept Pest-Related Information From Pest Management that Assists Silvicultural Procedures

As the full title of the "History of Crop Establishment and Tending" form implies, it is designed as a record to capture all pertinent operational information regarding the management of a young stand. It is not intended as the exclusive domain of Silviculture personnel, but, nevertheless, it specifically serves to record silvicultural practices.

Pest management on young stands can be regarded as one form of silvicultural practice and the presence of a pest, actual or potential, can play a major role in the silvicultural strategy for a young stand. It is a major recommendation of this Task Force, therefore, that the History Record System be expanded to adequately accommodate pest management surveys and treatments. This recommendation remains valid regardless of whether or not pest management develops an independent information system.

In summary, the History Record System could be readily adapted for pest management purposes on stands within the "opening" system. Major limitations would be its lack of applicability to mature stands, immature stands outside the "opening" system, stands not in the net operable land base, and its sometimes non-conformity with Inventory systems. Also, relative to state-of-the-art technology, the HRS is somewhat inefficient in its uploading, reporting, and mapping capabilities.

6. Resource Planning Section Consultations

As discussed in the introduction of this report, the Task Force recognizes that pest management must be fully included in the B.C. Forest Service's planning processes in order to fulfill its functions in the organization. It is through various planning processes that opportunities are identified to meet established management objectives and resources are optimally allocated to the chosen opportunities. To date, a lack of reliable pest-related data

has largely excluded pest management from B.C. Forest Service TSA and TFL planning and thus the effects of pest losses on yield analysis and AAC determination are not being properly incorporated.

Although "planning" in the broad sense of the word takes place at several levels in the Ministry of Forests, from provincial strategies and budget allocations to local operational tactics, the Task Force chose to concentrate on two pivotal and interrelated aspects: TSA Planning and Yield Analysis. Both of these are discussed below from the perspectives of where and how pest management can be included.

TSA Planning

There are two main purposes of TSA planning:

- (1) The Determination of Annual Allowable Cut (AAC). As the determination of AAC is assisted by yield analysis, the yield analysis process is really a component of TSA planning.
- (2) The selection of program options that will optimally support the chosen AAC.

There are several opportunities for pest management inclusion in the TSA planning process. Firstly, a specific pest problem can be identified as an "issue" to be resolved by the TSA plan. Secondly, pest management can be included in the yield analysis process itself at several points of entry. And finally, in the "Timber Strategies" section of a TSA plan, the harvesting, silviculture, and protection strategies are presented. Pest management should be included in all of these programs since the timing, location, and amount of harvesting, as well as the site preparation, reforestation, stand tending, and site rehabilitation options in silviculture can all be influenced by pest management.

Yield Analysis

In general terms, pest losses, or the gains from pest management, must be expressed as one of two impact types:

- (1) Mortality losses: This is significant stand kill, not just a few stems. Although annual mortality losses can be useful for the adjustment of short term harvesting levels, the information that is most needed for planning is a prediction of long term future mortality losses, expressed as a percentage risk. Unfortunately, there are two problems with this requirement. The currently used supply models cannot fully utilize this information if it were available, and the information is not available anyway because we are unable to predict future long term mortality losses. Modelling work being developed by Darrell Errico (B.C. Forest Service Research Branch) and Bill Reed (University of Victoria) for the prediction of wildfire risk, may have some potential for pest management application.
- (2) Incremental losses: These are stand level incremental losses, even though small amounts of mortality (at any one time) or tree form distortion losses may be involved. These types of losses could be handled in the currently used supply models, by adjusting the yield curves (volume tables), if the required data were available.

Specifically, there are six entry points for pest management input into yield analysis.

- 1) Identification of Issues: This is an important entry point for pest management as it determines whether a pest problem reaches several of the other steps in the yield analysis process. The TSA Steering Committees are responsible for the selection of the set of issues. In this regard, the "Black Book" exercise (the present and crude method for determining specific pest losses) has a vital role to play in the identification of pest management issues.

- 2) Inventory Update: As the yield analysis models use inventory information, it is important that volume depletions due to pests are included in the inventory database.

The best level of entry for pest management is to provide update information on a stand level (polygon) basis.

- 3) Net-Down Phase: Pest management can contribute to the identification of forest cover types that should not be included in the determination of AAC. For example, a percentage of balsam (Abies) type can be netted out in some TSA's where Balsam Bark Beetle is slowly eroding the volumes of these stands, but not sufficiently quickly to qualify for inventory disturbance updating.
- 4) Aggregation: The aggregation of inventory data (minus net-downs) into "Analysis Units" is tailor-made for each TSA and for each analysis of a TSA. "Issues," including pest concerns can influence how Analysis Units are constructed. For example, in the latest Quadra TSA Yield Analysis, six Analysis Units of Good, Medium, and Poor Douglas-fir sites for both the Mainland and Vancouver Island, were partly constructed in this format because this was the best way to express root disease losses.
- 5) Timber Supply Projections: There are various models that planning can use, including Timber RAM, FORPLAN, and MUSYC. MUSYC, an optimization model, is the one that is used most often.

Initially a "status quo" run is made as a basis for comparison. It is not simply a reworking of the previous yield analysis because new methods, new Analysis Units and an updated inventory base are used. Various "scenario" runs are then made which illustrate the potential effects of protection, silviculture and harvesting options. It is the choice, and construction of various regimes and constraints for these

"scenario" runs that pest management can have input. These include volume tables, economic tables, period of first harvest, period of last harvest, or the harvest profile (e.g. 50% from one analysis Unit, 25% from another, etc.).

- 6) Determination of AAC: Using the scenario runs as guidelines, the Chief Forester makes the final decision on the level of AAC. His decision is based on several factors including "infestations in and devastation of...timber on the area" (Section 7, Forest Act). This is an important aspect for pest management. The implication is that despite our current inability to predict long term mortality losses, from bark beetles for example, the AAC can be adjusted recognizing that there are hazards associated with maintaining a large inventory of susceptible timber.

It is a recommendation of this Task Force that reliable pest-related data must be used in the Yield Analysis process in order to truly determine the implications of pest impacts, identify opportunities, and optimally allocate B.C. Forest Service resources. These are expressed in TSA planning as the determination of AAC and the structure of the harvesting, silviculture, and protection programs.

7. Protection Branch Systems Specialists Advice

The systems specialists in Protection have developed and actively manage the provincial fire, weather, and lightning location data systems. Their continuing development of real-time computer applications for fire managers makes them uniquely qualified to offer sound advice for similar pest management systems. After discussions, they were asked to put their ideas in writing. The essence of their advice is as follows:

- sound pest management practices are simply good forest management practices

- most pest management activities will be actually executed by non-pest management personnel, such as timber management and silviculture practitioners
- pest management systems must become embedded into the systems and operations of these field practitioners, and not the reverse
- future pest management strategies will be demonstrated through yield prediction techniques and models that take into account pest dynamics and tree and stand growth projections with, and without, pest impact
- any Pest MIS must be able to collect and manipulate data that is tied to multitudinous geographic locations, and be able to track these through both space and time
- such a geodatabase can be maintained by hand, using mylar mapping, or by computer, using either polygons or grids. Each geographic location must be able to be linked to a list of attributes and because of the complexity required in the attributes list, these must be filed on computer systems.
- the operational system that comes closest to this requirement is the History Record System, but it is limited to "openings," whereas pests go beyond these. It also does not lend itself to historical tracking.
- if it is assumed that a Pest MIS will be operated locally from each district, then an intelligence network comprised of a sophisticated telecommunications network must link districts, regions, branches, and other users if it is to be an interactively useful system
- there are two options: either a centralized system operated at branch, or a decentralized system operated by each district
- the centralized "branch-run" system would be comparable to the History Record System, turnaround times would be slow, a significant increase in staff and funds would be required at Victoria, the system could be linked with the Inventory database but would not unify planning and operations at the district level
- the decentralized "district-run" system, on the other hand, would immediately foster working links with other activities such as silviculture, timber, planning, and inventory, where databases and systems would be automatically integrated and shared at the user level. The major drawback being the requirement for a sophisticated communications network and careful design of hardware and software to facilitate remote access to data by other users such as regions and branch. The prime advantage would be the direct responsibility at the user level.

- for the above reasons the decentralized "district-run" system is recommended
- because the decentralized system would require a rationalization of computer-uses by all activities, it implies a long-term vision of an integrated B.C. Forest Service computer network with implementation in gentle phases

8. GEOMAP

In order to make the Inventory Branch geodatabase accessible to the districts and regions, a system being developed by Pamap Graphics Ltd. of Victoria is being purchased (at the time of this report) by the B.C. Forest Service to serve as a core system to access, process, report, and update all forest inventory data by branch, district, and region personnel. Six units are to be purchased and implemented, one per region, by March 31, 1985. It is planned to eventually have one in each district.

The Task Force visited Pamap for a demonstration of the "core" GEOMAP program as well as prototypes of the "Planner" and "Surveyor" modules. The system is designed to operate on single user systems such as the IBM/PC, IBM/XT, IBM/AT, TEK 4170, and Wang Professional Computer. Currently the Wang Professional Computer is in widespread use in the B.C. Forest Service. For a detailed description of the GEOMAP system including hardware see Appendix V. A general description of the system is as follows:

- Hardware - includes microcomputer, colour graphics terminal, 30 x 30 cm digitizing tablet, colour copier
- options include larger digitizers and plotters

Software - GEOMAP consists of three main modules:

(1) Core module

- enables the import and export of IGDS geodata
- allows the user to review maps, window in, query, edit lines, digitize, and plot maps

(2) Surveyor module

- converts survey data to maps

(3) Planner module

- allows the user to overlay databases, perform analyses, and create management summaries

The GEOMAP system will access the inventory geodatabase by loading one map sheet at a time from computer disks. Initially, two 360 K diskettes are required to load all the information related to each map sheet. This system will likely improve in the near future as higher density storage disks become available, so that several map sheets can be loaded on a single disk or cartridge. There will be no "on line" linkage with Planning and Inventory Branch: disks will be exchanged by mail. This situation is not presently seen as a disadvantage as it is likely that, considering the volumes of data involved, an "on line" system would be prohibitively slow. Also, as previously mentioned, improved data storage devices will reduce the volume of disks being exchanged over time. In order to improve the responsiveness of the system in the future, more powerful computer hardware will be required, preferably a dedicated mini-computer for each system. This would enable more than one user of GEOMAP at a time.

While the GEOMAP system is initially being purchased for inventory purposes, the Task Force recognizes its potential for multi-disciplinary use including pest management. In particular, the following pest management activities could be carried out by GEOMAP:

- (1) Recording and storage of maps of pest outbreaks. Maps can be digitized and stored on disks.
- (2) Recording and storage of attribute information related to the pest outbreak polygons above, with flags to other information bases (e.g. Pest Management Tracking System). At present GEOMAP is limited to 66 characters of information but this can be expanded and most likely will be.
- (3) Estimation of area and timber attributes affected by pest outbreaks can be obtained by "overlaying" the pest polygon on the inventory cover map and querying the system for the attributes of the intersection of these two surfaces.
- (4) Estimation of timber at risk can be obtained by extracting appropriate information (e.g. areas, volumes) on susceptible cover types surrounding the pest outbreak from inventory base maps.
- (5) Update inventory cover maps by changing the shape or attributes of polygons which have been significantly changed by a pest outbreak. Revised maps stored on disk would be forwarded to Inventory Branch for change approval and system update.
- (6) Change in pest damage over time could be determined by "overlaying" the geodatabases of successive years over the inventory base maps and identifying the differences.
- (7) Providing district, regional, or provincial overview maps of pest damage by making a composite of individual maps. GEOMAP cannot currently handle this function but it would be a useful feature for future development.

While the potential advantages of the GEOMAP system for pest management are apparent, several years of research and development will be required before the GEOMAP system is fully functional for B.C. Forest Service purposes. In particular, the system may not be able to efficiently handle large scale infestations. Also, it will be several years until the entire province's forest inventory is digitized and available to all district and regional offices. Therefore, the use of GEOMAP (or an equivalent capability) for pest management will have to be considered a phase into which interim pest management systems will evolve. This should be kept in mind during the development and implementation of both the interim pest management systems and GEOMAP so that a smooth transition can take place and GEOMAP can be as useful as possible to pest management.

The obvious link at which the interim system should be compatible with GEOMAP is in the assignment of the 66 characters of attribute information recorded for each pest polygon. This should, at the very least, include a common reference number for each pest infestation centre number in order to link with any proposed pest management tracking system.

The GEOMAP system has potential for pest management purposes. The Task Force recommends that any Pest MIS implementation group actively participate in the development of GEOMAP in the B.C. Forest Service.

9. Results of the workshop with the Multi-disciplinary Systems Specialists

Much of this two-day discussion concerned four main areas - the Inventory Branch IGDS system; Silviculture Branch's History Record System; pest management data requirements for TSA Planning and Yield Analysis; and the flow and management of pest-related information from the field to the database, wherever that might be stored. The following is a condensation of the major points and concerns raised during the meeting.

- a geographic database is an essential requirement for any Pest MIS
- there is a need to carefully link the inputs/outputs of the History Record System and the Inventory System with an agreed-upon Pest MIS where the combined effect will best serve forest management purposes
- the consensus was that a Pest MIS should be developed which could utilize the computer assisted mapping (CAM) option available in Inventory Branch. This would allow both map and data updates within polygons or the creation of new polygons and data sets. While this would be a reasonable and middle-of-the road option, there are reasons why it can't be implemented on a province-wide basis for a few years. A simpler version is indicated in the interim.
- GEOMAP, if implemented at the district level, will soon require more storage and processing power if it is to fulfill requirements

- there will be a real problem in converting pest occurrence polygons (and their associated data) into Inventory polygons (and their associated data sets) caused by the potential inaccuracy of pest polygon determinations. If mapping standards are not met by Pest Management personnel, then there is the risk that good data in Inventory systems will be replaced by inaccurate data.
- Inventory Branch would not be interested in multiple updates of pest data because of their number and the costs involved. This means that pest management personnel must plan to store at least some polygon/data information for their own purposes, while other information must go to either the History Record or Inventory systems. Conceptually, this will be complex because of the differing requirements for different pests, and the associated systems that are either entrenched or continually evolving.
- in order to maintain standards and quality, a strong case can be made that a Pest MIS should be centrally controlled, either at Inventory Branch, or through Protection Branch to Inventory Branch. However, when considering efficiencies, an equally strong case can be made for an entry at source system.
- pest management requirements should have a strong influence on the evolution of Inventory systems and their input is required in conceptual development issues
- Silviculture's History Record System is designed to track and schedule treatments. Its limitations are that it applies to logged areas and not mature forests, it can't be updated directly, has limited storage capabilities, only handles data that is in the operable land base and does not track past history. These limitations mean that some important pest information cannot be handled.
- to be useful in yield analysis projections, a "snapshot" of current wood volume losses caused by pests is almost useless. What is needed is VAC information "with pests" and "without pests." This implies that some new research, and the consolidation of existing knowledge, are required to develop VAC's which account for both the presence and absence of the significant pests. A Pest MIS will not adequately resolve this need by itself.
- TSA planning and yield analysis processes require the identification of pest issues, a system that accurately updates forest inventory data, and timber supply projections that can incorporate the growth of forests over time with and without the effects of pest losses
- yield analyses are generally done in 5-year cycles and these don't necessarily coincide with pest outbreaks. Thus the impact of some outbreaks may have to be held in abeyance until the next TSA and yield analysis review.

- predictive models and revised VAC's require serious investigation. Their development must be considered as something separate from any current implementation of a Pest MIS. The dynamics of each significant pest and their influence on yield curves and forest age class distributions will be difficult to resolve but are most important for managing and scheduling forest harvests. The usefulness of permanent sample plots (both B.C. Forest Service and Forest Insect & Disease Survey) requires investigation here.
- there is a real need to break down the information system problem into modules and build the modules over time. This could be done most productively by a Protection/Planning and Inventory/Silviculture team approach. If this cannot be done, then a Protection Branch sponsored development team will be required.

10. Canadian Forestry Service/Forest Insect and Disease Survey (CFS/FIDS)
Update

Since 1946, staff of the Canadian Forestry Service's Forest Insect and Disease Survey (FIDS) have conducted overview surveys in British Columbia to provide data on pest identification, occurrence, and damage. Annual written reports (regional, provincial, and national) are produced and distributed, and a formal summary presentation is made annually to members of the Forest Pest Review Committee of B.C.

The national and regional objectives of the Forest Insect & Disease Survey are to:

Nationally

- (1) Produce a national overview of important pest conditions and their implications. This involves a yearly general survey to detect and monitor important forest insects and diseases.
- (2) Maintain records and surveys to support federal quarantine regulations concerning the movement of forest pests across boundaries.
- (3) Support forestry research through maintenance of records of pest occurrence and outbreaks, herbaria, insect collections, a national data bank, and making special collections or observations.

Regionally

- (1) Produce, in cooperation with the provinces, an annual regional or provincial overview of important pest conditions and their implications.
- (2) Conduct specific surveys of unresolved or potential pest problems.
- (3) Provide diagnostic and advisory services concerning forest insect and disease problems.
- (4) Provide a limited extension service to householders.

Since the formalization and expansion of the B.C. Forest Service's pest management capability in 1980, staff specialists have conducted site- and pest-specific surveys for stand management purposes. These surveys are conducted primarily to determine and incorporate major pest-caused losses in the Timber Supply Area (TSA) management process, and to conduct and assess pest control operations.

In order to minimize duplication of effort and maximize the quality, quantity, and compatibility of pest data collected, a "Memorandum of Understanding: Roles and Responsibilities Concerning Forest Insect and Disease Surveys in British Columbia" was signed by the B.C. Ministry of Forests and the Canadian Forestry Service, Pacific Region in August, 1984 (Appendix VI). The roles and responsibilities assigned to FIDS in this agreement are as follows:

- conducts annually an overview survey of B.C. to detect, monitor, and assess the occurrence and significance of forest pests
- maintains diagnostic services, specimen collections, and liaison with taxonomists
- maintains data on status of established and introduced pests, and conducts special surveys in support of quarantine regulations
- provides a variety of detailed reports on insect and disease conditions, especially at meetings of the Forest Pest Review Committee of B.C. and at meetings with B.C. Forest Service regional and district staff
- conducts relevant research to improve sampling techniques and methods to assess impact, and provides pertinent advice and transfer of technology

- includes appropriate data supplied by the B.C. Forest Service in the national forest pest data bank maintained by the Canadian Forestry Service
- participates in the development and maintenance of a comprehensive pest management information system for B.C.

In order to meet these responsibilities, FIDS (Pacific Region) currently has a staff of twenty-one people including eleven field rangers, a chief ranger, five insect and disease taxonomy staff, a mensurationist, a survey and sampling methods specialist, a secretary, and a manager. Field stations are maintained at ten locations in the province and the rangers work out of these from May to September each year.

The detailed methods used by FIDS to conduct pest surveys are described in the FIDS General Instructions Manual. A general overview of some of the more commonly used methods and systems as well as anticipated future system developments are presented here.

FIDS Data Bank

In order to maintain records on pest occurrence, distribution, and relative frequency, a computer data bank was established in Ottawa in 1952. Collection of standard, well-documented samples began in 1949. The currently used Forest Insect and Disease Survey Sampling Form (example in Brown and Davidson 1968) has been in use since 1967. A description of this form, the data bank, and storage and retrieval methods can be found in Brown and Davidson (1968) and Harris (1976).

A network of permanent sampling stations has been maintained in B.C. by FIDS since the early 1950's. Most of these are visited annually and standard pest population samples are conducted and recorded on the FIDS sampling form. This procedure is also followed at randomly selected sampling points. A sample of the insect or disease is sent to the FIDS insectary or herbarium along with the form where, upon positive identification, the pest species code

is recorded. This form, containing geographic (UTM coordinates) stand and pest data, is keypunched and the data subsequently transferred to the data bank in Ottawa.

Specific Pest Surveys

Specific pests have specific survey methods and often a unique sampling form. However, some generalities with respect to the methods used for these pests can be described.

The rangers locate pest problems through communication with government and company forestry personnel, ground observation, and aerial surveys. Infestations are mapped from fixed wing aircraft by hand sketching on 1:100,000 scale maps (or 1:125,000 or 1:250,000 if 1:100,000 maps are not yet available). In recent years some of the mapping has been done on a cooperative basis by B.C. Forest Service personnel. Areas of pest infestation are estimated by dot grid and volume affected is estimated based on the best available information, often from FIDS ground surveys on sample areas, or B.C. Forest Service information.

Ground surveys are generally conducted on at least a sample of each type of pest infestation in order to estimate the extent and intensity of damage as well as to collect mensurational and biological data to be used in predicting the trend of an infestation.

Data Storage and Access

At present maps and survey data sheets are stored in filing cabinets and accessed by hand. A computer database containing parasite records dating to 1950 is maintained by the Pacific Forest Research Centre insectary. The FIDS data bank in Ottawa is accessed through a written request including forms specifying the required information.

FIDS - BCFS Interaction

While there are some inherent difficulties in having two agencies conducting forest pest surveys in British Columbia, the objectives of the surveys and the magnitude of the forest land base and associated pest problems results in little duplication of effort.

The B.C. Forest Service has a responsibility to manage, protect, and conserve the forest resource, therefore they require maps and stand and pest data for those pests which could affect the timber supply in their district or TSA. The Forest Insect & Disease Survey, on the other hand, has a responsibility to provide a provincial overview of pest conditions. Their role is to "look at the big picture" and to work, in cooperation with research scientists, on pest population dynamics (including infestation trend predictions) and damage appraisal. Another difference between the two agencies is that FIDS surveys all forest pests whether or not they are significant at the time, whereas the B.C. Forest Service conducts operational surveys of the significantly damaging pests. As a result of these different roles and objectives and the different expertise residing in each agency, the B.C. Forest Service and Forest Insect & Disease Survey efforts should be complementary.

Information transfer between the two agencies has been and is presently in paper form. Forest Insect & Disease Survey rangers exchange maps by hand or mail with B.C. Forest Service district and regional protection personnel. Data is generally requested by telephone or mail and supplied in the same way. The only field form shared by both agencies is the FIDS sampling form for pest identification. B.C. Forest Service personnel can obtain and use the FIDS sampling form and submit copies of the form along with a pest specimen to the FIDS herbarium or insectary where it will be identified and a copy of the completed form returned to the sender. Any B.C. Forest Service request for information from the FIDS data bank is through a written request to FIDS. The type of information presently in this data bank (pest distribution and

relative frequency) is not frequently requested by operational pest management personnel in the B.C. Forest Service so this method will probably continue to be acceptable in the future.

A possible direct link with the B.C. Forest Service systems in the future would be through GEOMAP. If FIDS obtained a GEOMAP system it would allow them to access the B.C. Forest Service inventory geodatabase and to exchange maps with B.C. Forest Service districts in the form of disks. However, because of the differences in scale at which the two agencies work it would have to be determined whether or not there would be sufficient value to FIDS in obtaining the level of detail this system would offer.

Future Developments in FIDS

The Forest Insect & Disease Survey is currently embarking on a program to update and standardize (with other FIDS regions) its data storage and retrieval methods. A research and development team based at the Petawawa National Forestry Institute in Chalk River, Ontario has been given this assignment. In 1985 the FIDS data bank will be transferred from Ottawa to the Petawawa National Forestry Institute. The structure and function of the data bank will be reviewed and means of improving access developed. The 80 column format currently used in the data bank and on the associated FIDS sampling form will be reviewed, as improvements in computer storage over the years no longer necessitate this restriction.

Another area of improvement that is being examined is the use of computer mapping and analysis software and hardware of the GEOMAP type. The Forest Insect & Disease Survey, Pacific Region is currently evaluating a system called OVERLAY on a research and development contract with Northwest Digital Research Ltd. of Vancouver. It is anticipated that in the near future FIDS will enter and store its maps by computer and utilize software that enables map and data analysis. The ability to overlay geodatabases and the improved map access should enable FIDS to provide more accurate and precise pest damage and damage trend estimates.

Another subject being studied is how to improve the forest inventory data used by FIDS. As a result of the overview scale at which FIDS works, it is impractical in many cases to access and utilize the inventory database of the B.C. Forest Service. In recent years the federal government has been developing a forest inventory for Canada which utilizes provincial data aggregated to an average 10 km x 10 km grid (Bonnor 1978, 1982; Bowen et al. 1981). This database presently resides at the Petawawa National Forestry Institute. The Forest Insect & Disease Survey is examining the possibility of directly accessing and utilizing (where appropriate) this inventory base, probably as a geodatabase on a computer mapping and analysis program. Other options for improving inventory information are also being examined.

APPENDIX IV

ANNOTATED LIST OF PERSONS OR GROUPS CONSULTED REGARDING AVAILABILITY OF
PREVIOUSLY DEVELOPED PEST MANAGEMENT INFORMATION SYSTEMS

(a) USDA-Forest Service

Region 1

Missoula, Montana
Contact: Ralph Johnson
No system, referred Task Force to MAG

Region 2

Lakewood, Colorado
Contact: Berni Remo
Referred Task Force to MAG

Region 4

Boise, Idaho
Contact: Ron Beverage
Forest Pest Management
State and Private Forestry

Ron Beverage has developed a geographic information system (GIS), called PEST. This system is programmed for a Hewlett-Packard 9845T, produces coloured maps and calculates areas affected, but not volume depletions. Beverage is working with USDA-FS, Region 8 (see below) to include soil type and ecological information to devise hazard rating systems. The MAG in Colorado (see below) has at least partially utilized Beverage's system.

The Task Force obtained a copy of this system with example output maps. Our conclusion is that this system is only slightly more sophisticated than aerial sketch maps and dot counting for area determinations. The current B.C. Forest Service inventory systems (IGDS and associated attribute files) have superior potential capability for determinations of area, volume, and timber types affected.

Region 8

Atlanta, Georgia
Contacts: Harvey Toko
Director, Forest Pest Management

Harold Flake
Field Representative
Forest Pest Management
Asheville, North Carolina

Region 8 has developed a "Southern Pine Beetle Information System." This system can be used on an "Apple II," and calculates the number of trees affected, their growth potential, and projects volume losses. They are working with Ron Beverage in Region 4 to include GIS capability and a hazard rating system.

Conclusions of the Task Force are similar as for Region 4, above.

Region 9

Eastern Region
Milwaukee, Wisconsin

No Pest MIS; referred Task Force to National Headquarters for USDA-FS in Washington, D.C.

National Headquarters

Washington, D.C.

Contact: Fred Honing
Assistant Director
Forest Pest Management

Although the entire USDA-FS is updating its information handling capability by going onto a computer system called DATAGENERAL, they have no comprehensive Pest MIS, as such, other than the system being developed by the MAG (see below).

METHODS APPLICATION GROUP

Fort Collins, Colorado
Contact: Bill White
Forest Entomologist

Has researched other systems, says there are few.

Mentioned southern pine beetle (see Region 8, above, and reference Coulson et al.) and Ron Beverage systems (Region 4, above). Their system, Integrated Pest Impact Assessment System (IPIAS) (see references Ciesla, Daniel, Pence, Young) will link the U.S. forest inventory base on System 2000 with a Geographic Information System (GIS) (originally developed as Map and Overlay and Statistical System [MOSS] by the US Fish and Wildlife Service) and stand and pest models.

(b) Ontario Ministry of Natural Resources

Contact: Joe Churcher
Forest Entomologist

There are no adaptable systems in the eastern provinces. They either rely on the Canadian Forestry Service, Forest Insect and Disease Survey or have a paper and mylar system.

(c) University of B. C. - Faculty of Agriculture

Contacts: Dr. Short
Dr. H. Shreyer

Referred Task Force to DIALOG

(d) DIALOG

This literature search service turned up 154 annotated citations from CAB Abstracts, CRIS, and NTIS databases, using ("Information System" or "Data Base") and ("Pest Management" or "Agriculture") as keywords.

None of the citations was pertinent to the Task Force objectives.

APPENDIX V

PAMAP

GEOMAP ... Micro Mapping System

GEOMAP is a standalone mapping system of interest to:

- o INTERGRAPH users requiring map display and update facilities in remote centres
- o cartographers who wish to utilize classified image data to update maps
- o users with complete, yet low-volume, mapping requirements
- o INTERGRAPH users with a need for front end processing

GEOMAP is a suite of micro-based modules that provide interactive digitizing and editing for landuse functions. Based around the Tektronix 4107, this package supports up to 16 map levels containing lines, labels and links to the data base. It also provides the capability of displaying a LANDSAT satellite image classified to 7 themes.

The map may be loaded or updated from:

- o a hardcopy map, or portion thereof, registered on a tablet
- o a multi level INTERGRAPH IGDS file
- o a classified image displayed on the screen and registered locally to the map

Using a basic menu, with personal computer style window menus the user can easily choose the visible levels, the style of depicting linkages and the image to be displayed. A windowing function provides various methods for specifying a portion of the map for detailed work, or the entire map for overview.

In edit mode, the user can input a complete map or alter an existing map. GEOMAP supplies various means of inputting lines, labels and linkages to a data base. Deletions are highlighted for verification. Lines can be broken for partial deletion.

Linkages, areas and distances may be queried. Hardcopy can be achieved by transferring the screen image to an ink-jet plotter, or producing a scaled line plot.

INTERGRAPH design files can be downloaded to GEOMAP for display and edit, and GEOMAP files can be transferred to INTERGRAPH.

For further information, please contact:

Software Product Manager
PAMAP Graphics Limited
301 - 3440 Douglas Street
Victoria, British Columbia
Canada V8Z 3L5

Telephone: (604) 381-3838
Telex: 049-7232

GEOMAP SYSTEM CONFIGURATIONS

For implementation of GEOMAP on the clients existing single user systems, such as the IBM/PC, IBM/XT, IBM/AT, TEK 4170, and WANG PC (with the PC emulation card) that have a minimum of 512K memory, RS-232-C communications port, a 8087 floating point processor and a hard disk.

1.0 BASE CONFIGURATION

The following package features a small scale digitizer and plotter:

Tektronix 4107 colour graphics terminal	\$12,843
Tektronix 4957 12"x12" digitizing tablet	1,454
Tektronix 4695 colour copier	2,744
GEOMAP software (first copy price)	7,500

TOTAL	\$24,541

2.0 DIGITIZER OPTIONS

A number of digitizing alternatives are supported. These include:

Calcomp 9100 series - 36"x48"	from \$9,555
- 44"x60"	from \$10,655

3.0 PLOTTER OPTIONS

A number of plotter alternatives are supported. These include:

DEC LVP16 11"x17" pen plotter	\$2,849
Calcomp 1040 series 34"x50"	from \$12,790
Calcomp 1070 series (drum/bed)	from \$26,700

** All prices quoted are in Canadian funds. GEOMAP and Tektronix prices are effective January 15, 1985 and are valid until 28 February, 1985. Provincial Sales Tax is not included. Some delivery charges may apply.

TEKTRONIX HARDWARE SPECIFICATIONS

page

TEKTRONIX 4107 - COMPUTER DISPLAY TERMINAL

- 640 by 480 pixel resolution
- 13 inch screen (9.5 x 7 inch) viewing area
- True zoom and pan
- Internal 256k of RAM for storage of picture elements
- RS-232-C communication rates of up to 38.4K baud
- Two additional RS-232 ports for connection of peripherals such as plotters and tablets
- One parallel port for interfacing devices like the TEK 4695
- 16 colours selectable from a palette of 64
- VT100 compatible
- Operating temperature range of +10 to +40 degrees C
- Relative humidity range of 10 to 75%, non-condensing
- Nominal Line Voltage of 115v or 230v at 48-66Hz
- Input Power of 200 Watts

TEKTRONIX 4957 - GRAPHICS TABLET

- 16.5 x 15.5 inch tablet
- Maximum digitizing area of 11 x 11 inches
- Resolution is user selectable up to 1,000 points per inch
- Speed is user selectable up to 90 coordinates per second
- Connects to the RS-232-C port on the TEK 4107

TEKTRONIX 4695 - COLOUR GRAPHICS COPIER

- 120 dots/inch addressability in both the horizontal and the vertical
- Eight colours (using half tones up to 125 different shades are available)
- Typical output size is 8.5 x 11 inch
- TEK 4107 image size is 8 x 10.6 inch
- Copy time depends on image density (3 to 6.5 minutes)
- Copy paper is available in roll (8.5 in wide) or sheet format (8.5 x 11)
- Separate snap-in cartridges allow in colour to be replaced as needed
- Interface is "Centronics" compatible parallel and can be connected to port on the TEK 4107
- Line Voltage same as TEK 4107
- Input Power of 120 watts

APPENDIX VI

MEMORANDUM OF UNDERSTANDING:

ROLES AND RESPONSIBILITIES CONCERNING
FOREST INSECT AND DISEASE SURVEYS
IN BRITISH COLUMBIA

Objective: The objective of the Memorandum of Understanding is to provide for coordination and cooperation between the Ministry of Forests and the Canadian Forestry Service in the timely monitoring, identification, information storage and reporting of the occurrence of forest insects and diseases, and for the accurate assessment of their damage to forests in British Columbia. The improved quantity and quality of such data will benefit both organizations as well as resource managers with forest industry and parks services.

Background: Since 1946, staff of the Canadian Forestry Service's Forest Insect and Disease Survey (FIDS) have conducted overview surveys in British Columbia to provide data on pest identification, occurrence and damage. Annual written reports (regional, provincial, national) are produced and distributed, and a formal summary presentation is made annually to members of the Forest Pest Review Committee of B.C. This information is used for developing appropriate pest management programs or other forest management activities.

Since the formalization and expansion of the Ministry of Forests' pest management capability in 1980, staff specialists have conducted site- and pest-specific surveys for stand management purposes. These surveys are conducted primarily to determine and incorporate major pest-caused losses in the Timber Supply Area (TSA) management process, and to conduct and assess pest control operations.

There is need to maintain a strong working relationship between FIDS personnel and pest management specialists in the Ministry of Forests to ensure that information gathered by both organizations is of high compatibility, especially for planning subsequent operations either to prevent or suppress forest losses.

Roles and Responsibilities: The Canadian Forestry Service, through its regional FIDS unit:

- Conducts annually an overview survey of B.C. to detect, monitor and assess the occurrence and significance of forest pests;
- Maintains diagnostic services, specimen collections and liaison with taxonomists;
- Maintains data on status of established and introduced pests, and conducts special surveys in support of quarantine regulations;
- Provides a variety of detailed reports on insect and disease conditions, especially at meetings of the Forest Pest Review Committee of B.C. and at meetings with B.C. Forest Service Regional and District staff;

- Includes appropriate data supplied by the Ministry of Forests in the national forest pest data bank maintained by CFS;
- Participates in the development and maintenance of a comprehensive pest management information system for B.C.

The Ministry of Forests, through pest management specialists at Protection Branch and at Regional and District offices:

- Conducts site-and pest-specific surveys for stand management purposes, largely as follow-up to early information from FIDS;
- Provides estimates of selected pest impacts for TSA Planning and management purposes and for pest control operation;
- Supports special pest-related surveys for silvicultural, inventory or timber harvesting purposes, and provides relevant information from these surveys to FIDS;
- Maintains a basic identification and information service on major pests at Regional offices;
- Supports annual FIDS field surveys by (i) coordinating and providing aircraft for overview surveys based on identified needs, (ii) hosting spring and fall meetings at Regional offices to plan and coordinate activities and to report on findings to all concerned agencies, and (iii) providing financial or other support for special activities as required and as resources are available;
- Maintains expertise in forest pathology and forest entomology at Protection Branch and at Regional offices to work with FIDS on projects of mutual concern;
- Maintains a Pest Management Information System, including selected FIDS data to facilitate forestry operations throughout the province.

Implementation: The Canadian Forestry Service and the Ministry of Forests, by means of the roles and responsibilities identified above, will work towards optimizing and complementing the capabilities of both organizations. A Forest Pest Survey Planning Committee, composed of representatives from both organizations meeting at least each spring, will be largely responsible for the maintenance of this working relationship. Special needs and formal arrangements will be referred to the executive levels of both organizations for recommendation, resolution or endorsement.

"D.S. Lacate"

Program Director, Forest Environment
Canadian Forestry Service
Pacific & Yukon Region

"August 27, 1984"

Date

"H. G. Doerksen"

Director, Forest Protection
Ministry of Forests

"August 3, 1984"

Date