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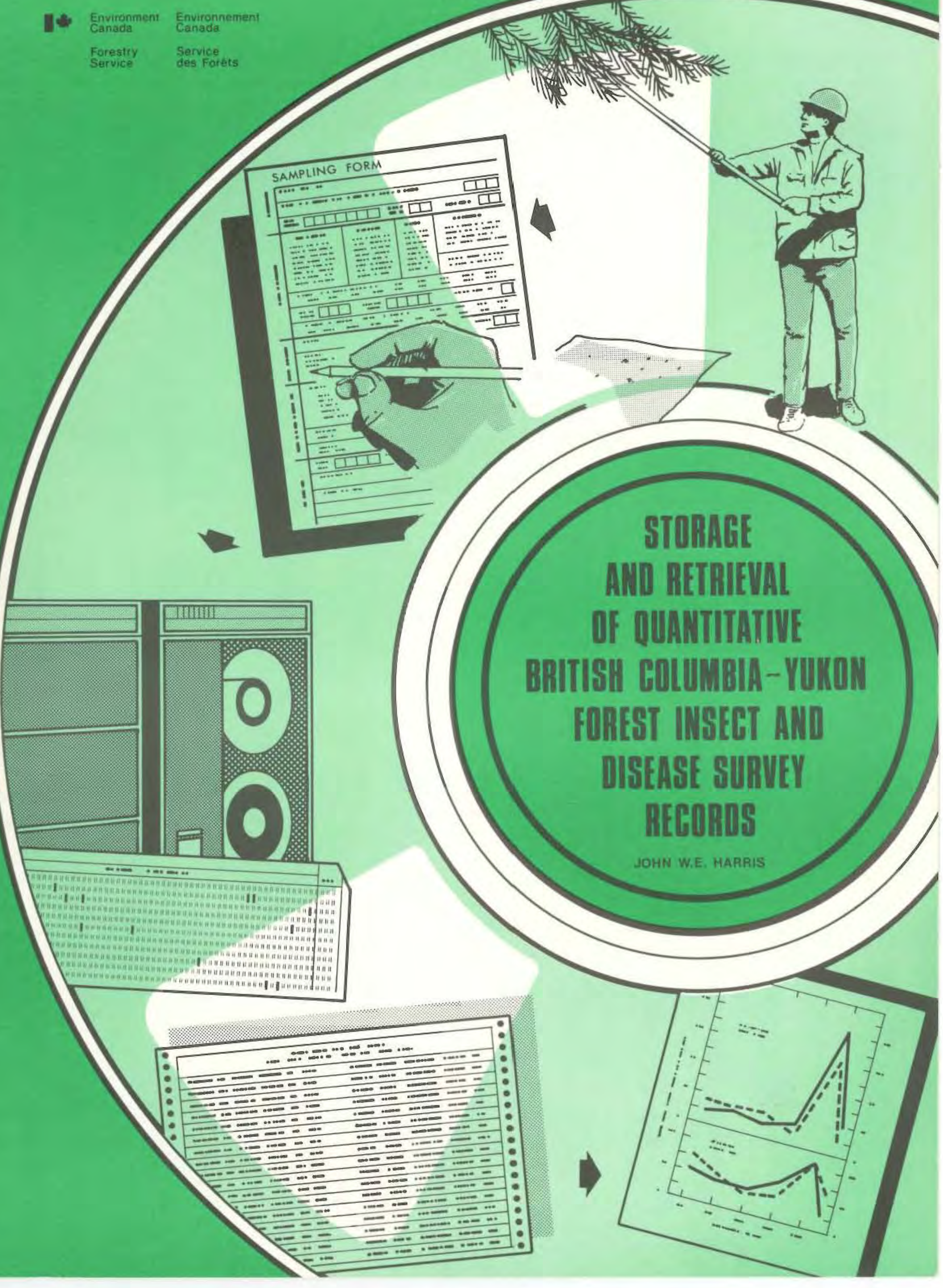

STORAGE AND RETRIEVAL OF QUANTITATIVE BRITISH COLUMBIA–YUKON FOREST INSECT AND DISEASE SURVEY RECORDS

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ABSTRACT

The Forest Insect and Disease Survey , established in 1936, and now part of the Canadian Forestry Service, Department of the Environment, collects and interprets data on forest pest populations for the benefit of forest land managers. These data are used for current population and damage prediction, and are stored on a computer file for possible future analysis.

The most complete and extensive long-term records are on defoliating insects, for which there has been a standard collecting technique applied since 1949, at established sampling points throughout the Province. The methods of data collection and retrieval are described in this report. Data are extracted by computer programs which a) list it in several formats: by collection, pest species and locality; b) print pest population and sample distribution listings and maps; c) calculate and summarize insect population measures such as average number of insects per sample and % positive samples. These measures, for any insect pest, host tree and geographic location, can be plotted and compared. Methods of access to Atmospheric Environment Service weather data were also developed and the data can be print-plotted.

RÉSUMÉ

L'inventaire des maladies et des insectes forestiers, fondé en 1936, faisant partie du Service canadien des forêts, ministère de l'Environnement, récolte et interprète des données sur les fléaux des forêts en vue de faire progresser l'aménagement des forêts. Depuis ces données on estime les populations actuelles et on prédit les dommages. Puis on classe celles-là au moyen de fiches d'ordinateur en vue d'analyses futures.

On possède les données les plus complètes et détaillées, s'échelonnant sur une longue période, sur les insectes défoliateurs, pour lesquels on se sert de la même technique de récolte depuis 1949 dans les mêmes places-échantillons çà et là dans la province. Ce rapport décrit les méthodes de récolte et le rassemblement des données. Puis des programmations à l'ordinateur fournissent les données suivantes: a) énumérations selon les récoltes, les espèces de fléaux, et la localité; b) impression des énumérations et des cartes des populations et des répartitions selon les échantillonnages; c) calculs et résumés des mesures des populations d'insectes telles que le nombre moyen d'insectes par place-échantillon et le pourcentage de places-échantillons où tel insecte fut trouvé. Ces mesures, pour tout insecte nuisible, arbre hôte et localisation géographique peuvent être mises en plan et comparées. On a aussi mis au point des méthodes d'accès aux données météorologiques du Service de l'environnement atmosphérique, données qui peuvent être pointées par impression.

INTRODUCTION

Forest pest surveys in Canada are carried out by the Canadian Forestry Service field staff, assisted by provincial and industrial foresters. The purpose of these surveys is to collect and analyze data on forest pests, report on current populations and damage, and predict future conditions.

Data were first taken regularly in British Columbia in 1937, beginning one of the most extensive long-term series of biological population records in the world. Collection of standard, well-documented samples began in 1949; approximately 160,000, each including from one to several insect or disease species, have been made, and these are the principal records available for study.

Studies of population trends were done by a number of workers (e.g., Silver 1962; Ruth and Silver 1966), but it was not practical to make greater use of the data until the advent of computers. Now that some 27 years of computerized data are available, plus over 12 years' prior written records, it is desirable to examine the historical data for more detailed information, with the aim of using predictive knowledge in effecting control. Should analyses yield inconclusive or erroneous results, modifications may be invoked to detect deficiencies and improve data collection methods in the future.

Analysis of the data requires that it be correct and readily accessible. The author has worked on improving the data file and has developed a basic series of programs to facilitate batch retrieval of the data. This report describes these methods, with emphasis on defoliating insect records, which make up the largest single data base, and the formulation of some methods to correlate pest and some related weather data. Modification of these techniques will follow use of the data; many refinements undoubtedly are possible. Comments and discussion, therefore, are welcome.

DATA COLLECTION AND STORAGE

The basic document for all samples is the Forest Insect and Disease Survey Sampling Form (Figures 1-A, 1-B). This form has been in use since 1967; prior to that, other versions were used. After completion, it is filed at the Pacific Forest Research Centre in Victoria. A sample of the pest and/or damage may accompany the forms for identification, retention in the museum collection, rearing for parasites or some other special reason.

General information is recorded about the stand, such as location, elevation, aspect, maturity, tree size, density and forest cover type, and pest data such as host, sampling technique data, and the name, number and stage of all insects. National codes have been adopted whereby both insect and tree species are assigned a distinctive number.

The geographic location of samples are recorded by two methods. One involves 88 distinct geographic regions or drainage divisions. Generally, they include entire river drainages, but some of the larger systems are sub-divided. More definitive than these broad subdivisions is the Universal Transverse Mercator (U.T.M.) grid, which divides the country into blocks measuring 10,000 metres on each side.

To record more information than can be handled by the regular sampling form, such as from certain specialized surveys, the data base was expanded in 1971 by the introduction of a supplementary sampling form (Figure 2). This form and the regular sampling form are linked through a common registration and specimen number. Maps and various other field forms are used during the actual surveys; at convenient intervals, a summary of the data is transferred to the sampling forms. For example, after each day's aerial surveys, information, such as the number of dead trees or area defoliated, is recorded for each significant area of damage.

Data were originally retained only on the field sampling forms but, in 1952, were transferred to Remington cards; in 1967, the more common and versatile 80-column card format was adopted. These data, described here, are being made accessible by a number of programs developed under the direction of the author.

While evidence of damage and actual pest numbers for a variety of pests are included in Survey records, the principal quantitative data have been on defoliating insect larvae. These are sampled mainly by the tree-beating method (Harris et al. 1972) which involves a standard-sized sample or collection (3-trees, 12-ft beating pole, 7 x 9-ft collecting sheet). Collections, taken at least once a year at locations representative of the surrounding stands, are marked and designated as "permanent sampling stations (P.S.S.)". These are visited each year during the time when larvae of the majority of pests are present.

Permanent sampling stations are groups of trees, usually selected from within less than half a square mile, sampled routinely each year . They represent a timber type covering a much larger area, and are chosen with a view to sampling one or more (preferably all) of the significant species of defoliators occurring within that type.

The number of P.S.S.s established in a timber type is theoretically proportional to the amount of that timber type in the District. The actual selection is governed by: (a) accessibility (by vehicle or aircraft); (b) distribution of forested area and important forest types; (c) insect and disease hazard rating, i.e., those having chronic or periodic pest problems, and (d) permanence (in firebreaks, parks, etc.).

FOREST INSECT & DISEASE SURVEY SAMPLING FORM

1. INSECT 2. DISEASE

LOCATION

COLLECTION POINT (be specific) — NEAREST POST OFFICE

LOCALITY (use Forest Dist. or Div. or Drainage Div. or Political Sub-Div. or FIDS Dist.) [2]

UTM GRID DESIGNATION [5] — PLOT OR SAMPLE AREA NO. [12] — ELEVATION [14]

STAND EXAMINED

[16] DESCRIPTION
1. Nursery
2. Ornamentals
3. Plantation (Nat. Sp.)
4. Plantation (Exot. Sp.)
5. Shelterbelt
6. Hedgerow
7. Woodlot
8. Natural forest
9. Treed swamp
0. Scattered individuals

[17] HISTORY
1. Undisturbed
2. Clear cut
3. Selective cut
4. Burned
5. Insect damaged
6. Disease damaged
7. Animal damaged
8. Climate damaged
9. Wind damaged
0. Water damaged
-. Agriculture

[18] ASPECT
1. North
2. Northeast
3. East
4. Southeast
5. South
6. Southwest
7. West
8. Northwest
9. Flat

[19] MATURITY
1. Seedling (nursery)
2. Transplant (nursery)
3. Seedling (forest)
4. Sapling
5. Young growth
6. Semi-mature
7. Mature
8. Over-mature

[20] AGE STRUCTURE
1. Even 2. Two 3. Uneven

[21] BASAL AREA (Circle code of nearest no. of sq. ft.)
1. (33) 2. (66) 3. (99) 4. (132) 5. (165) 6. (198) 7. (221) 8. (254) 9. (287) 0. (320) -. (353) +. (386)

FOREST SECT. [22] — COVER OR SUB-TYPE [25] — DOMINANT SPECIES [29]

[30] HEIGHT OF DOMINANT TREES (Circle code of nearest ht. in ft.)
1. (0.5) 2. (1.5) 3. (3) 4. (7) 5. (15) 6. (30) 7. (45) 8. (70) 9. (100) 0. (140) -. (180) +. (210)

TREES SAMPLED

TREE SPECIES [31] — NO. OF TREES SAMPLED [34]

[36] STATUS
1. Living
4. Rec. dead stndg.
5. Rec. dead cut
6. Rec. dead fallen
7. Old dead stndg.
8. Old dead fallen
9. Manufactured

[37] TREE CLASS
1. Dominant
2. Codominant
3. Intermediate
4. Suppressed
5. Undergrown regen.
6. Understory tree
7. Fringe
8. Open
9. Old vet.

DATA ON INSECT(S) OR DISEASE(S)

[38] SAMPLING TECHNIQUE

Qualitative		Quantitative
1.	Beating	2.
3.	Hand picked	4.
5.	Traps	6.
7.	Ground observation	8.
9.	Aerial observation	0.
-.	Photography	+.

[39] POPULATION LEVEL OR INCIDENCE
1. Negative
2. Trace
3. Low
4. Moderate
5. High
6. N.A.

[40] COLLECTION SOURCE
1. Flower
2. Fruit
3. Buds
4. Old foliage
5. New foliage
6. New shoot
7. Branch
8. Stem
9. Butt
0. Root
-. Duff or soil
+. N.A.

SAMPLE UNIT NO. — NUMBER OF UNITS [41] — DAMAGE & HAZARD INDEX

COUNT PER UNIT — AV. COUNT [43] — [46]

GENERAL

FIDS NO. (See codes on cover) [47] — LAND OWNERSHIP (See codes on cover) [49] — DAY [50] — MO. [52]

COLLECTOR

ADDRESS

REMARKS & SYMPTOMS

1

Figure 1-A - Field sampling form used by Forest Insect and Disease Survey since 1967. Side 1.

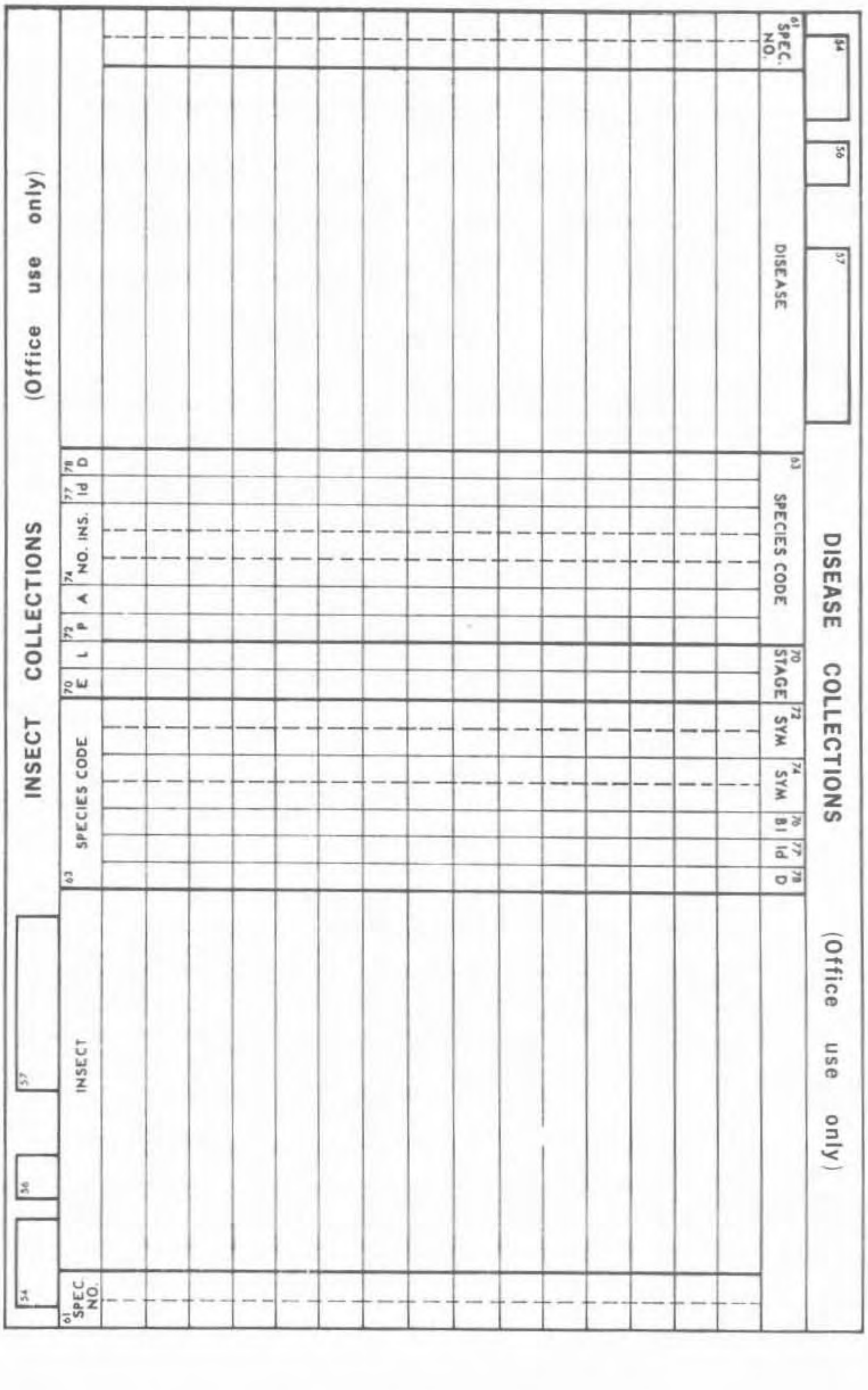

Figure 1-B - Field sampling form used by the Forest Insect and Disease Survey since 1967. Side 2.

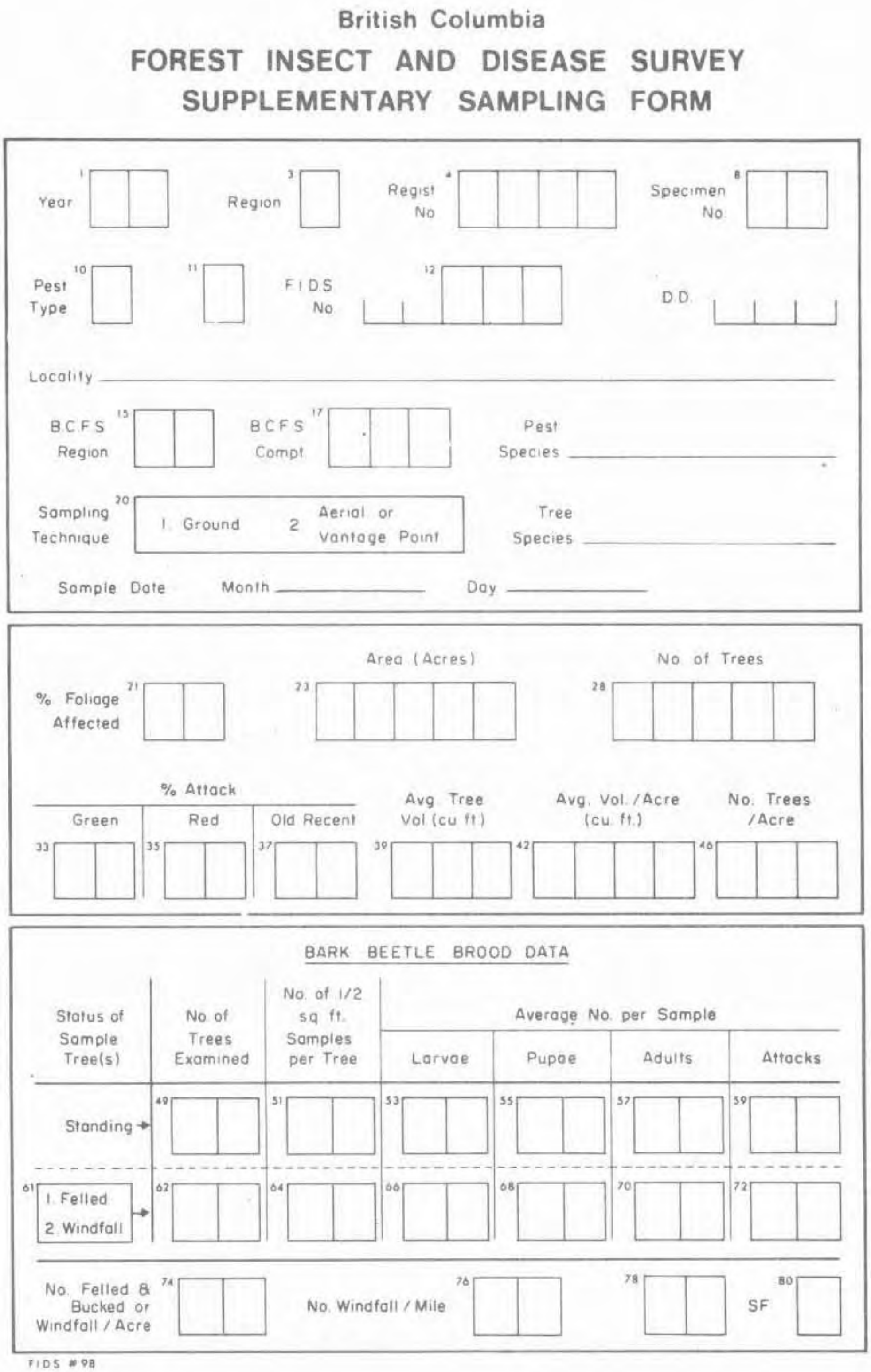

Figure 2 - Supplementary sampling form used by the Forest Insect and Disease Survey since 1971.

If a P.S.S. must be relocated, every effort is made to choose an area of similar type in the same grid; in which case, the original P.S.S. number is retained.

Areas where chronic insect problems occur are among those suitable for P.S.S.s. Situations that would make a stand unique for only a short time, such as disease centers or other predisposition factors, are avoided.

A regular sampling form is completed for each beating collection made at a P.S.S. Collections at other points are similarly recorded; random beating collections may supplement the P.S.S., but special beating collections to appraise an infestation are not included in calculations designed to demonstrate annual population changes over the larger test areas.

DATA RETRIEVAL

Population Measures

Three quantitative measures of defoliating insect populations are in use by the Survey in British Columbia. They are: 1) % positive samples, where the number of samples which include at least one of a particular insect species is expressed as a proportion of the total; 2) average numbers of specimens per sample, and 3) average numbers of specimens per positive sample. These parameters can be calculated for any particular pest insect species, host tree species and location(s) for the period of the year the pest is in the larval and/or pupal stage. An example is given in Figure 3.

The first of the above measures, % positive samples, may show population changes more distinctly than the second and third, and indicates the distribution of insects in the stand, which may be independent of the numbers of larvae in the samples. Small numbers of insects, evenly spread, can result in high % positive collections, indicating a potentially significant problem should populations increase.

The second and third measures tell about the population in actual numbers of insects per sample. An advantage of the latter index, where the number of positive collections include only those with at least one specimen of the insect in question present, is that it is easier to calculate than the former. Negative samples (those that could include the insect in question but do not, and which are not, therefore, labelled by that pest's code number) normally are not separately identified and counted. To find the total number of eligible samples (positive plus negative), rather complicated selection procedures must be followed. However, ignoring negative samples introduces a bias and may result in a less sensitive index at low population levels; in general, this author prefers the former method.

All methods are susceptible to sample selection bias. Samples concentrated in an infestation represent it, but not any larger area. If there is a tendancy toward selecting sampling sites favored by an insect, such as by taking additional samples within an infestation, population figures will be higher than if there were no such selection. Samples taken in earlier years, when access was more limited and permanent sampling stations were less carefully established than now, are particularly suspect. In recent years, most samples are taken at routine permanent sampling stations and it is less likely that "additional" or biased collections could affect the conclusions.

Choosing the Sampling Period

The sampling period for most defoliator larvae on foliage is during spring and early summer. Ideally, all sampling should be done within as brief a period as possible to minimize the influence of natural mortality. Also, most samples can be designed to account for at least several species, but it usually happens that their entire periods of occurrence do not completely coincide, so the practical sampling period is one which coincides with the occurrence of most or all of the species occurring in an area.

For the purpose of determining insect density and deciding on acceptable negative samples, methods of determining a workable sampling period for each insect were tested:

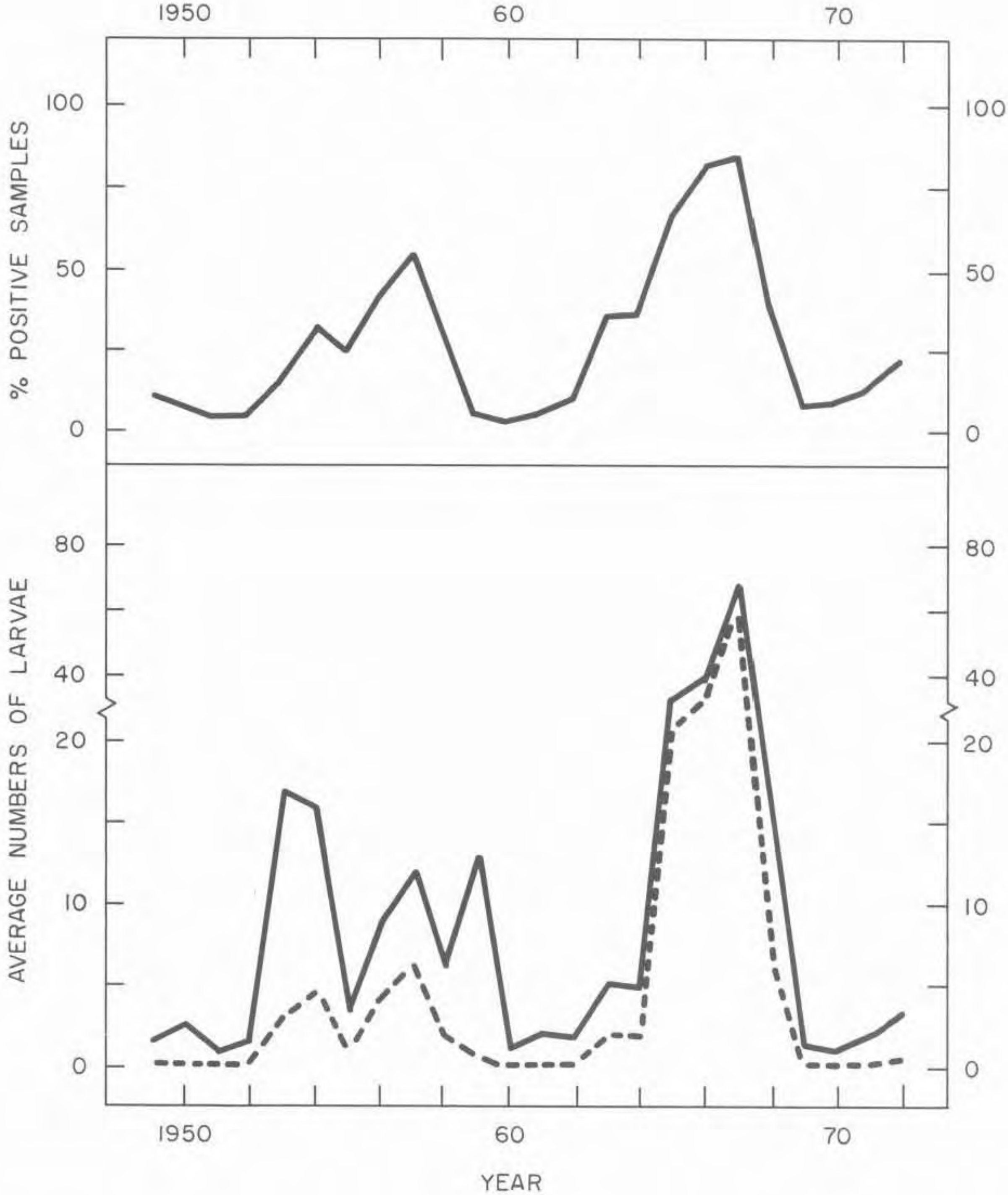

Figure 3 - Comparison of % positive samples (upper graph), average numbers of larvae per sample (- - -), and average numbers of larvae per positive sample (——) (lower graph). Host: *Tsuga heterophylla*; Insect: *Acleris gloverana*; Sample location: Southern interior wet belt.

(1) include all samples, knowing or at least assuming that they were made when the pest being studied could have been present;

(2) include all samples from the date of the first collection containing that pest to the date of the last one also including it.

(3) include all samples between specified dates, by selecting a specific period each year or calculating an average period over several years.

In recent years, the actual time of sampling has tended to be well within the period of major larval activity. Thus method one, which is convenient to calculate, is satisfactory for at least the past several years' records. The second method is more suitable for the older records, when the sampling period was more protracted. It can be automatically calculated but may exclude some valid negative samples at either end of the period. The third method would probably give the most accurate results, but it needs adequate knowledge about the populations, which is usually not available, especially in the case of historical samples, and it cannot be readily calculated like the other two, requiring the input of data specific to each case.

A comparison of these methods, for a pest species on two hosts and at two localities (Figures 4 and 5), illustrates how all three methods can produce results that almost coincide; such a check would be useful in deciding on a method in any particular case.

Appraising Sampling Site Localities

Sampling areas can vary considerably in their sensitivity to pest population changes; therefore, it is desirable to select and perpetuate the most representative sampling stations. In this way future sampling is improved, with maximum accuracy and minimum effort, time and expense.

One way of identifying the better existing sampling sites is by looking at their comparative histories. Population changes should be more readily seen at sites where populations are regularly high than at sites where they are low. However, there may be sites where larvae are seldom found, except when overall populations are unusually high; in such cases, finding even a few larvae can be indicative of an impending problem.

Quick searches of the data file by computer are now possible, facilitating examination of existing sampling sites in a variety of ways. Since the smallest geographic area definable is the U.T.M. grid, computer-printed maps and data listings by year and grid, described in a later section of this report, show pest populations on areas this size and larger. By reference to maps for each year, one can determine sites:

(1) where samples were made regularly, and

(2) where larvae were found in abundance (or the reverse) compared to other sites.

The first-mentioned point is important because a historical study requires fairly continuous annual records at a locality. Each grid can be scanned to determine

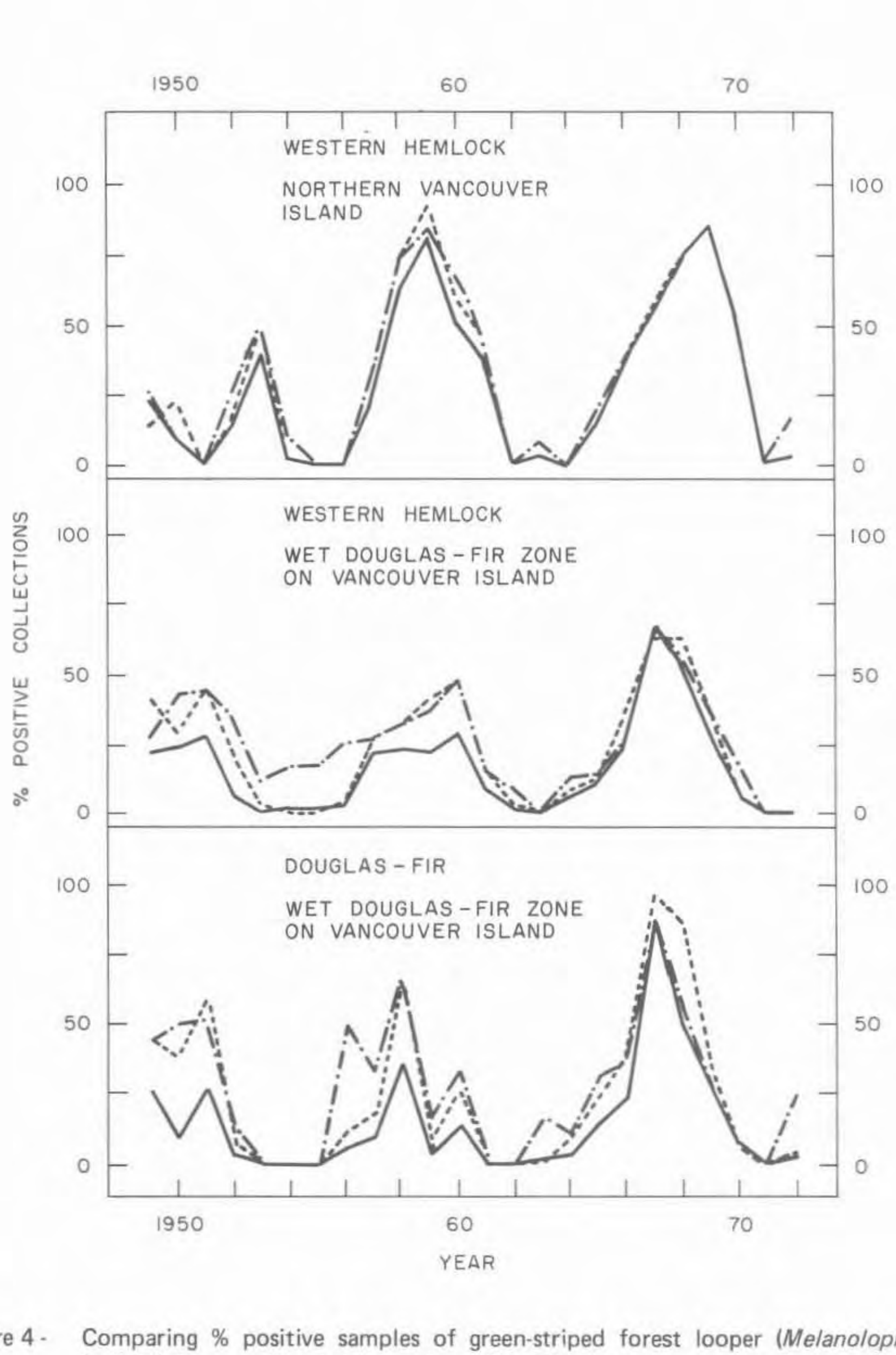

Figure 4 - Comparing % positive samples of green-striped forest looper (*Melanolophia imitata*) larvae when total number of beating samples are calculated, using 3 methods for determining sampling period: 1. All samples (——) 2. Samples from first to last occurrence of pest (-·—·-) 3. Samples falling within average sampling period (- - - - - - -).

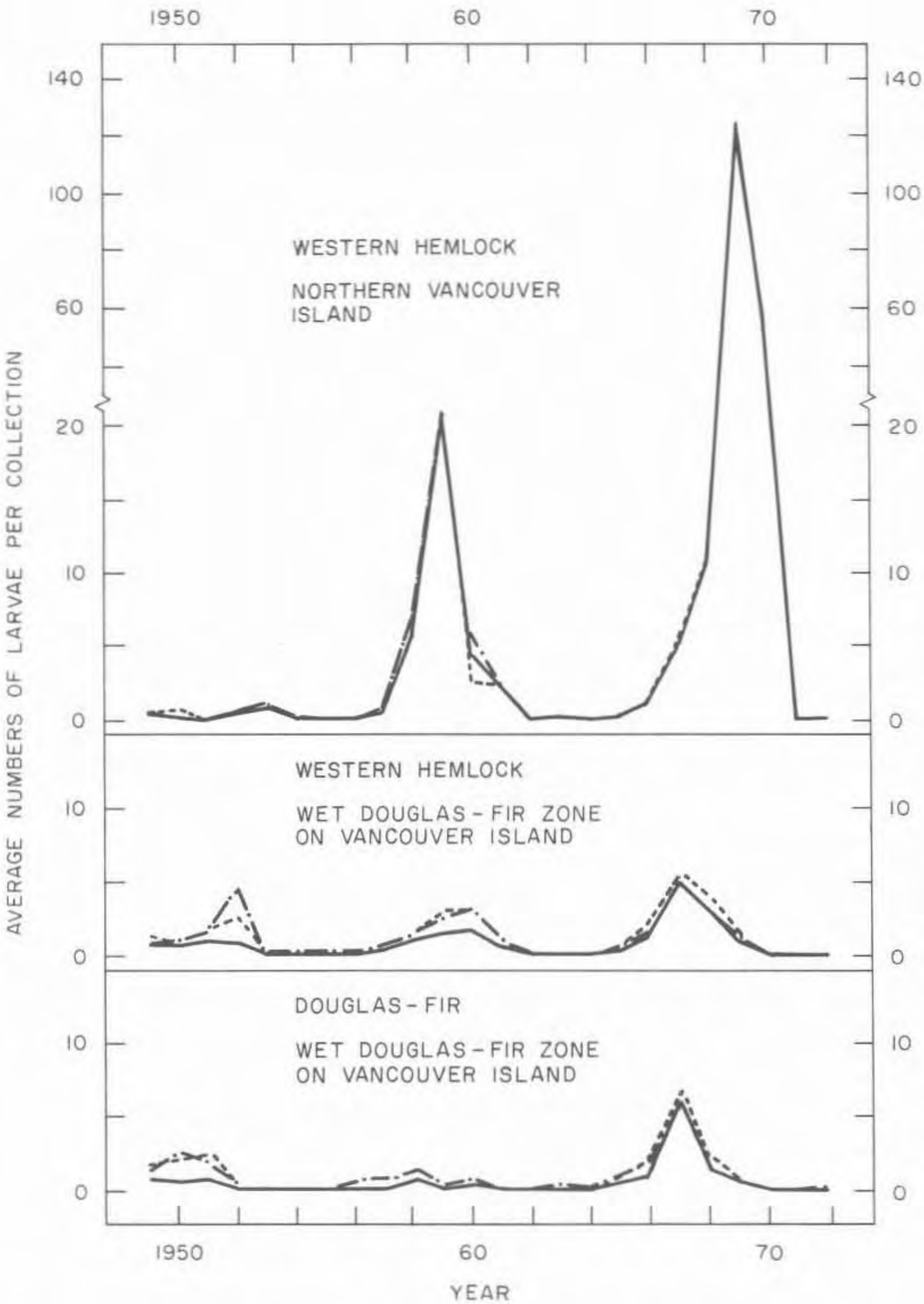

Figure 5 - Comparison of average numbers of green-striped forest looper (*Melanolophia imitata*) larvae per sample when total number of beating samples are calculated using 3 methods for determining sampling period: 1. All samples (———). 2. Samples from first to last occurrence of pest (·—·—·—). 3. Samples falling within average sampling period (-------).

the number of years during which some samples were made, and those with data for only a few years can be ignored. Then, point number 2, the numbers of larvae of each insect and host in each year by grid can be examined. Grids with more than a minimum number of sample records and with some positive records (for the pest being studied) in the 27 years could be given further attention. An initial measure of a grid's usefulness, a locality rating, is the ratio of years in which there were positive samples to total years sampled. These ratings can be plotted for particular insect pests and host species to determine grids that are sampled frequently. But this does not provide information on the number of insects in the positive samples. To add this information, wherever locality ratings are more than some minimum figure, population figures are plotted. A further refinement is to determine grids in which more than one insect species has been significant; the more species of insects that appear at a sample point, the more useful it becomes. Above-average sampling sites can thus be identified for specific insects and hosts. Points identified in this manner can be used as population indicators, and insensitive points can be eliminated, with consequent savings.

To illustrate the previously described techniques, some sampling points on Vancouver Island were examined for their usefulness in recording *Acleris* sp. on western hemlock. Locality ratings for points where five or more annual samples were taken were plotted by grid on a map (Figure 6). On grids where locality ratings were more than 3 (30% positive samples over 5-23 years), a coded larval value was plotted in each grid each year for *Acleris* (Figure 7). The higher values indicate larger numbers of *Acleris* were recorded.

Figure 8-A shows grids with at least two insect species having a locality rating of 3 or greater. These are good localities for general beating samples and would probably have top priority. Figure 8-B shows a refinement of this, indicating grids with specific numbers of insect species with a 3 or greater rating. The darker the grid in the figure, the more species frequently have been collected in this grid. One should not exclude heretofore unsampled areas from future sampling but, of the existing sites, the darker areas on the above figures probably are the better grids to sample regularly.

Extracting Pest Data

A number of computer programs have been developed to extract, list and summarize the pest population data. The listings consist of the recorded data pertaining to each sample, with the record for each pest species in a sample on a separate line; tree and stand data are identical for all pest species in each sample. The first sorts are usually by region (British Columbia-Yukon in our case) and by year. The major programs currently in routine, regular use are as follows:

1. Accession listing - Lists the 80 entries of data found on each sampling form, repeating it for each different pest species found in each sample. They are arranged in order of the arrival of each sampling form at the laboratory, at which time the form is given a survey or accession number. All samples, regardless of sampling method, are included (Figure 9). It is useful for checking the accuracy of data.

2. Species listing - Same as the above listing, but arranged by insect or disease species. Within each species, the 80-column records are arranged by year and then by drainage division; within each drainage division, they are by tree species; within this, by sampling

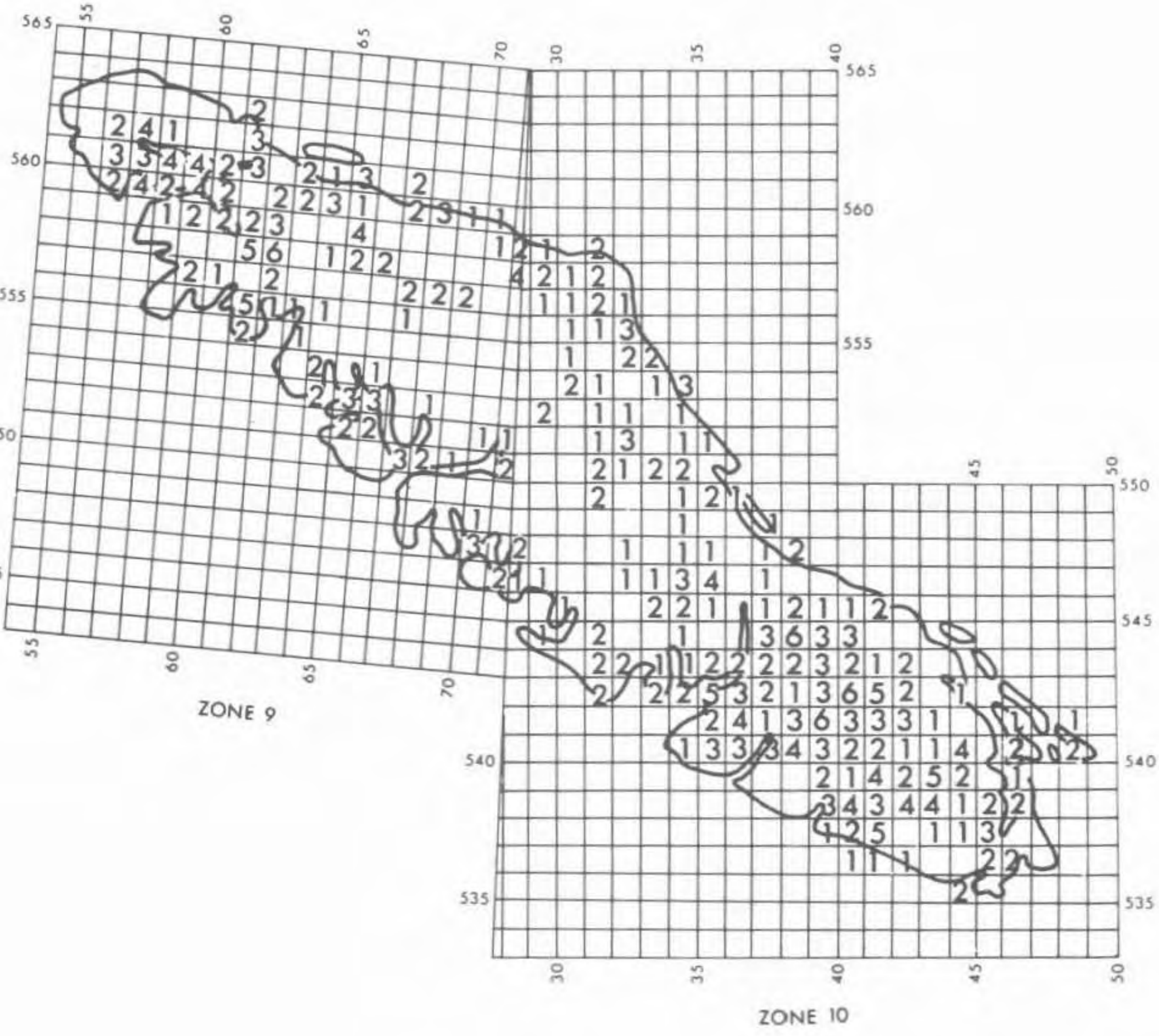

Figure 6 - Locality ratings for *Acleris gloverana* on western hemlock on U.T.M. gridded map of Vancouver Island. Ratings are % positive samples at each point where samples were taken from for 5-23 years; i.e., "3" indicates 30% of samples taken at that point were positive.

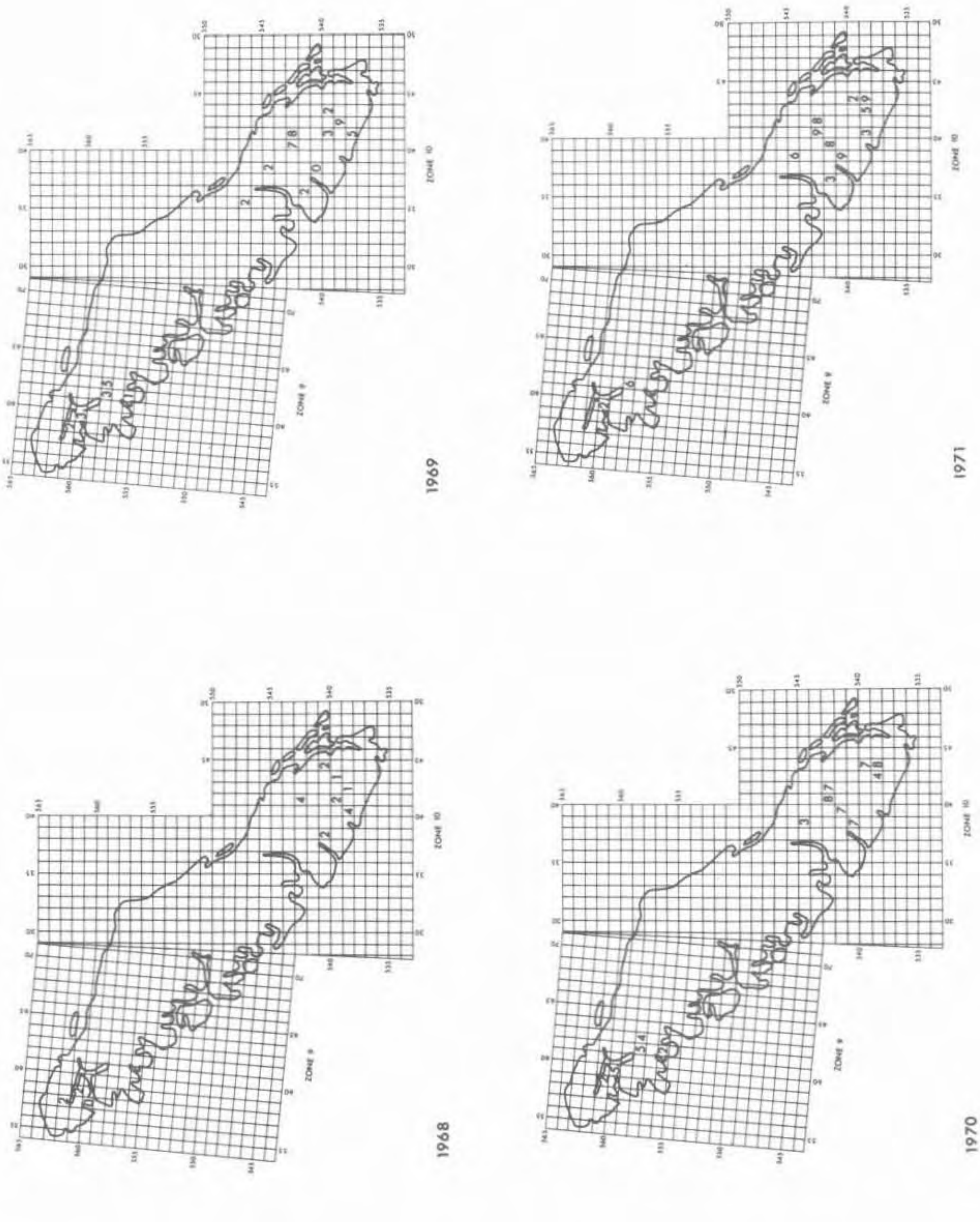

Figure 7 - Maps showing highest numbers of larvae (coded) of *Acleris gloverana* in collections on western hemlock in each grid with a locality rating of 3 or better (30% or more positive samples over 5-23 years). Maps each show data for 1 year, 1968-71.

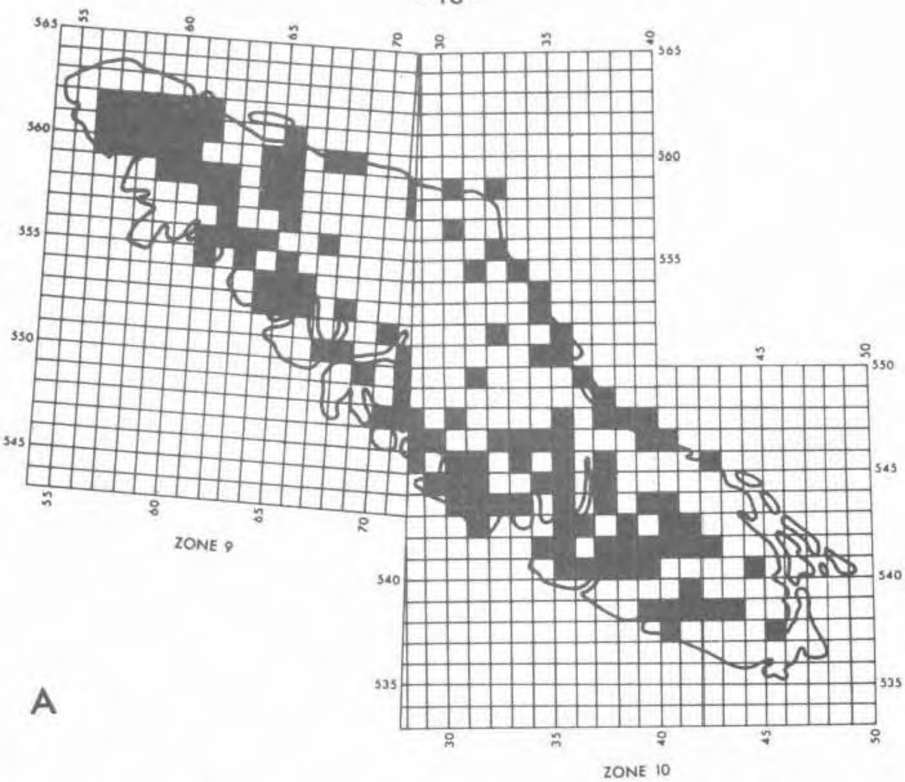

Figure 8-A - U.T.M. grids on Vancouver Island with at least two insect species on western hemlock with a rating of 3 to 10 (30% or more positive samples over a 5- to 23-year sampling period).

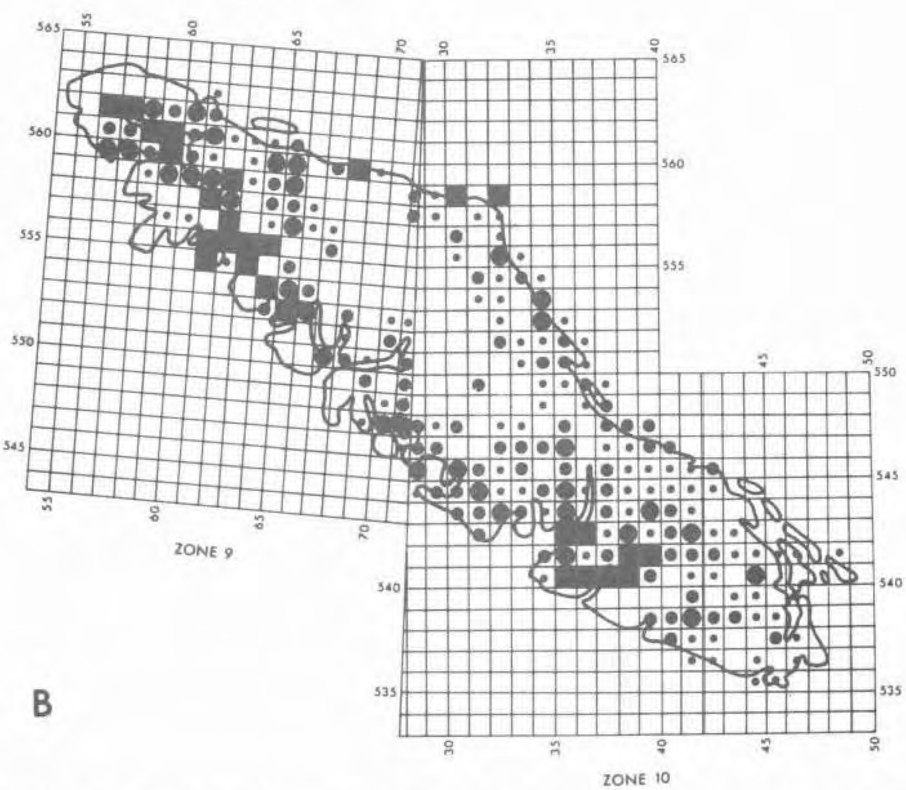

Figure 8-B - U.T.M. grids on Vancouver Island showing the number of insect species with a 3 to 10 rating. Number of insect species:

1 2 3 4 or more. The darker the square the better the sampling point.

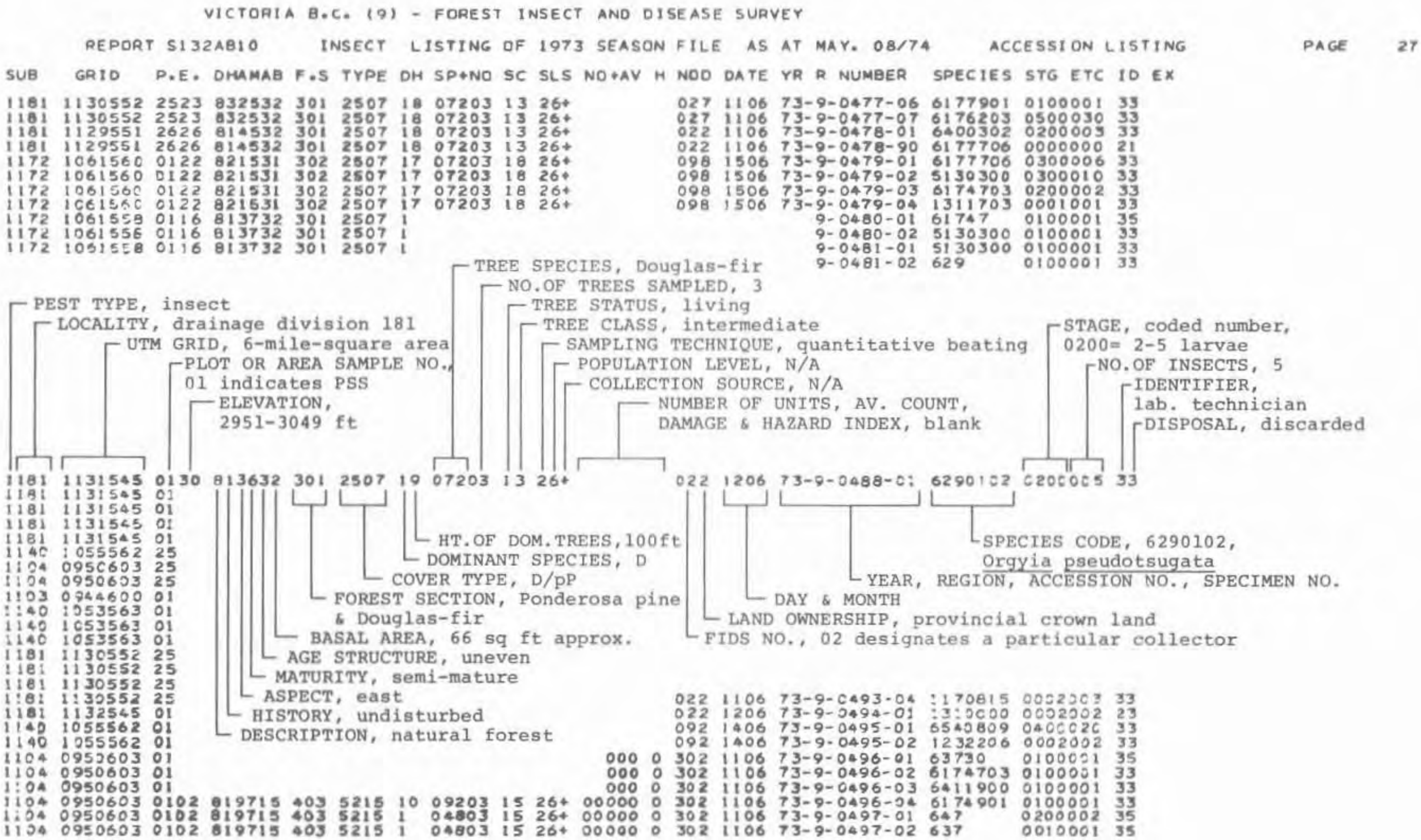

Figure 9 - Accession listing. A listing of sampling form data with entries in order of reception at laboratory (see Figure 1). One entry is described in detail above.

technique and then by date. This enables one to examine records grouped in the most commonly used way: by insect species, locality and host.

3. Sample count listing - Similar to accession listing, but restricted to 3-tree beating samples, and data are grouped by drainage division, tree species and date. Since 1971, only quantitative permanent sampling station and random beating samples are listed. It is used principally to enable one to count the total number of beating samples by locality and host tree; this can be used, together with the species listing, to calculate % positive samples and average number of larvae per sample.

4. Population calculation program - Calculates % positive samples and average numbers of larvae per sample or positive sample for any specified insect(s), host(s) and geographic area. Data are from 3-tree insect beatings and, after 1971, are also restricted to quantitative permanent sampling station and random beatings.

   These figures are automatically calculated for a) the entire sampling period, and b) the period between first and last positive samples. Six-day counts of numbers of positive samples, total numbers of collections, and numbers of insects are listed so that calculations can be made for other sampling periods.

   This program provides some of the information also obtainable from 2 and 3 above, but with fewer hand calculations being necessary (Figure 10).

5. Mapping program - Produces computer-printed maps of British Columbia-Yukon Region, giving sample or population distribution by year. Coded values are located within each 10,000 meter-square grid, indicating either the total number of samples on specified tree hosts(s) or the highest number of larvae-pupae (Figure 11) of specified insect species on any host(s).

6. Grid listing - Prints out, by U.T.M. grid and year, the data on the above maps. The print-outs show, by grid, the number of samples for any specified tree host(s) (Figure 12) and the highest numbers of larvae-pupae of any specified insect species on its host(s). From this, one can see the localities that have been sampled frequently, infrequently or not at all, and of the sampled localities, those that have had consistently high or low numbers of larvae.

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                    FOREST INSECT AND DISEASE SURVEY                                          PAGE  1
     REPORT SI36HA          POPULATION DATA FOR YEAR 1975                      DATE OF REPORT  09/07/75
  SPECIES            61777   (                  )  6177700 (             )  6177701 (            )  6177706 (N. FREEMANI      )
  HOST               071 (D  )    072 (D  )
  DRAINAGE DIVISION  184

1184113355901158396323012507180720318 26+     021120675902450164707  020000233  0
1184113356325158196323012500180720313 26+     027160675903050261777060200002 33  1
1184113456201148546323012500180720313 26+     027160675903070161767020100001 33  0
1184113456001158125323012500180720313 26+     027160675903080261777060100001 33  1
1184113255902228367343012500190720313 26+     028240675905580361777060200004 53  1
1184113056201128116323012507180720318 26+     028240675905600461777060900325 53  1
1184113255901188196323012500180720312 26+     028250675906330461777060400011 53  1
1184113156301198197333012500190720312 26+     028250675906360561777060400018 53  1
1184113156001318387323012505190720318 26+     028250675906370151303000200004 23  0
1184113456225148136323012500180720313 26+     027250675906380161767020200002 53  0
1184113456225178177333012500190720312 26+     027250675906430361777060400018 53  1

  MONTH OF JUNE                               DAYS 1-6   DAYS 7-12   DAYS 13-18   DAYS 19-24   DAYS 25 UP
  TOTAL INSECTS (POSITIVE LARVAE/PUPAE)           0          0            3           329           47
  NO. POSITIVE COLLECTIONS (LARVAE/PUPAE)         0          0            2             2            3
  TOTAL COLLECTIONS                               0          1            3             2            5

1184113756301138195335015242190720313 26+     022020775909830165408090200001 53  0
1184113355901198136323012505180720313 26+     028180775914560162901020100001 53  0

  MONTH OF JULY                               DAYS 1-6   DAYS 7-12   DAYS 13-18   DAYS 19-24   DAYS 25 UP
  TOTAL INSECTS (POSITIVE LARVAE/PUPAE)           0          0            0             0            0
  NO. POSITIVE COLLECTIONS (LARVAE/PUPAE)         0          0            0             0            0
  TOTAL COLLECTIONS                               1          0            1             0            0

  TOTALS FOR THE YEAR

  A. TOTAL NO. OF INSECTS FOR RECORDS HAVING POSITIVE LARVAE/PUPAE                      379
  B. TOTAL POSITIVE LARVAE/PUPAE COLLECTIONS                                              7
  A/B. AVERAGE NUMBER OF LARVAE/PUPAE PER POSITIVE LARVAE/PUPAE COLLECTION             54.1
  C. TOTAL COLLECTIONS                                                                  13
  A/C. AVERAGE NUMBER OF LARVAE/PUPAE FOR ALL COLLECTIONS                              29.2
  B/C. PERCENTAGE POSITIVE LARVAE/PUPAE COLLECTIONS                                    53.8 %
  D.   TOTAL COLLECTIONS IN POSITIVE PERIOD                                            10
  A/D. AVERAGE NUMBER OF LARVAE/PUPAE PER COLLECTION IN POSITIVE PERIOD                37.9
  B/D. PERCENTAGE POSITIVE L/P COLLECTIONS IN POSITIVE PERIOD                          70.0 %
```

Figure 10 - Population calculation summary. For specified insect species, host trees and localities, calculates population numbers. Also gives 6-day totals of numbers of samples (collections), positive samples and larvae-pupae.


```
HIGHEST LARVAE

          SECTION = 10    YEAR 1975

          INSECT SELECTION: 61777   6177700 6177701 6177702 6177704 6177706
          HOST SELECTION: 071 072

           MAP CODE STRUCTURE
          0=0 . 1= 1. 2 =2-5. 3 =6-10. 4 =11-20. 5 =21-40. 6 =41-60. 7 =61-100. 8 =100-200. 9 = 200+

THE REFERENCE POINTS ARE

          X(1) = 50  Y(1) =590

          X(2) = 50  Y(2) =610

          X(3) = 50  Y(3) =630
```

Figure 11 - Computer map of part of southwestern British Columbia showing the coded highest number of *Nepytia freemani* larvae found in 3-tree beating collections on Douglas-fir in 1975, in each 10,000-metre-square grid. Dots outline rivers, lakes and coastal areas; asterisks define the B.C. border; arrows, plus signs and numbers in brackets indicate approximate U.T.M. grid coordinates.

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GRID / YEAR TABULATION - SI36HE <

INSECT SELECTION: ALL
HOST SELECTION: 092

NO. OF COLLECTIONS

UTM	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78
10-43-538					1							2	2		1	2	1	1	2	1	4	2	4	2	3					
10-43-539									1		1			1				1		2	1	2	1	2	1	1				
10-43-540	2	1		1					1		1	1	1			2		2		1										
10-43-541		1		1	1				1	1				1								1								
10-43-542	3	1	1	1	2	1	1	1		1						1			1	2			1							
10-43-543	1	2										1		1			1			1			1			1				
10-43-544									3																	1				
10-43-545												1		1																
10-43-548			2	2								2		1	2	2	2	2	1	3	1	2	2	1	1					
10-43-549	7		1	1	4	1	1	1		2	8	3	7	6	4	6	8	6	2	1	1	1								
10-43-550	2		1				2			7	2		6	6	4	2	1	2	2	1					1					
10-43-551	6							2		1	2	1	2	2	2	5	2	3	1		1	1				1				
10-43-552								2			1			2	2	1	2	3	1			1								
10-43-553						1				2								1	2	1			1		1	1				
10-43-554	3									1			1	2		1	1	3	2		2									
10-43-555													1	1	1			1	1		1									

Figure 12 - Grid listing. Gives the coded number of 3-tree beating collections for specified host tree species by grid and year.

Geographical-Ecological Data

Pest data are always summarized for some discrete, geographical area of some biological or political significance. Few good ecological classifications of British Columbia are available, although some parts have been studied in more detail than others. The major classifications are by Rowe (1972) and Krajina (1965), who used climate, geology and vegetation to classify areas with similar features. While these areas have been described and shown on maps, and undoubtedly have use in grouping pest population records, they do not describe in detail the actual site on which each particular observation is made; there are no classifications that have been developed in sufficient detail to identify definitely the varied conditions covered by each of our sampling stations.

An example of one of the better described areas is Vancouver Island. By using drainage divisions or U.T.M. grids applied over an ecological map, similar areas from which to select samples can be delineated. References for subdividing Vancouver Island are Packee (1972), Rowe (1972) and Krajina (1965). One approach would be to group several survey drainage divisions with roughly similar ecological characteristics (Figure 13). Another would be to use Packee's subzones, delineated by grid, with grid squares including more than one subzone excluded. Such a partitioning is illustrated in Figure 14. Pest population records could be extracted and summarized for these geographic areas, and population figures plotted for them.

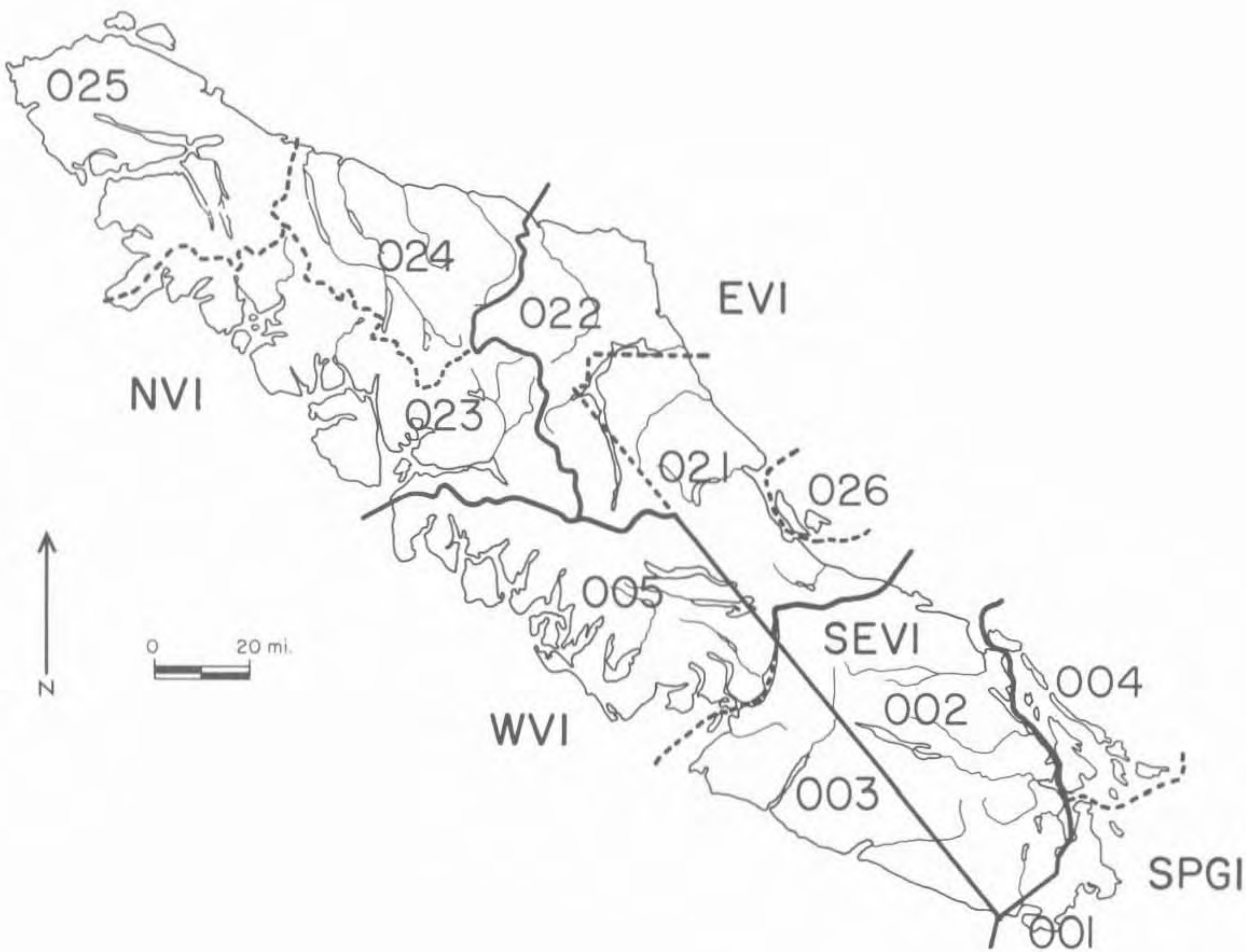

Figure 13 - Vancouver Island drainage divisions grouped by similar ecological factors.

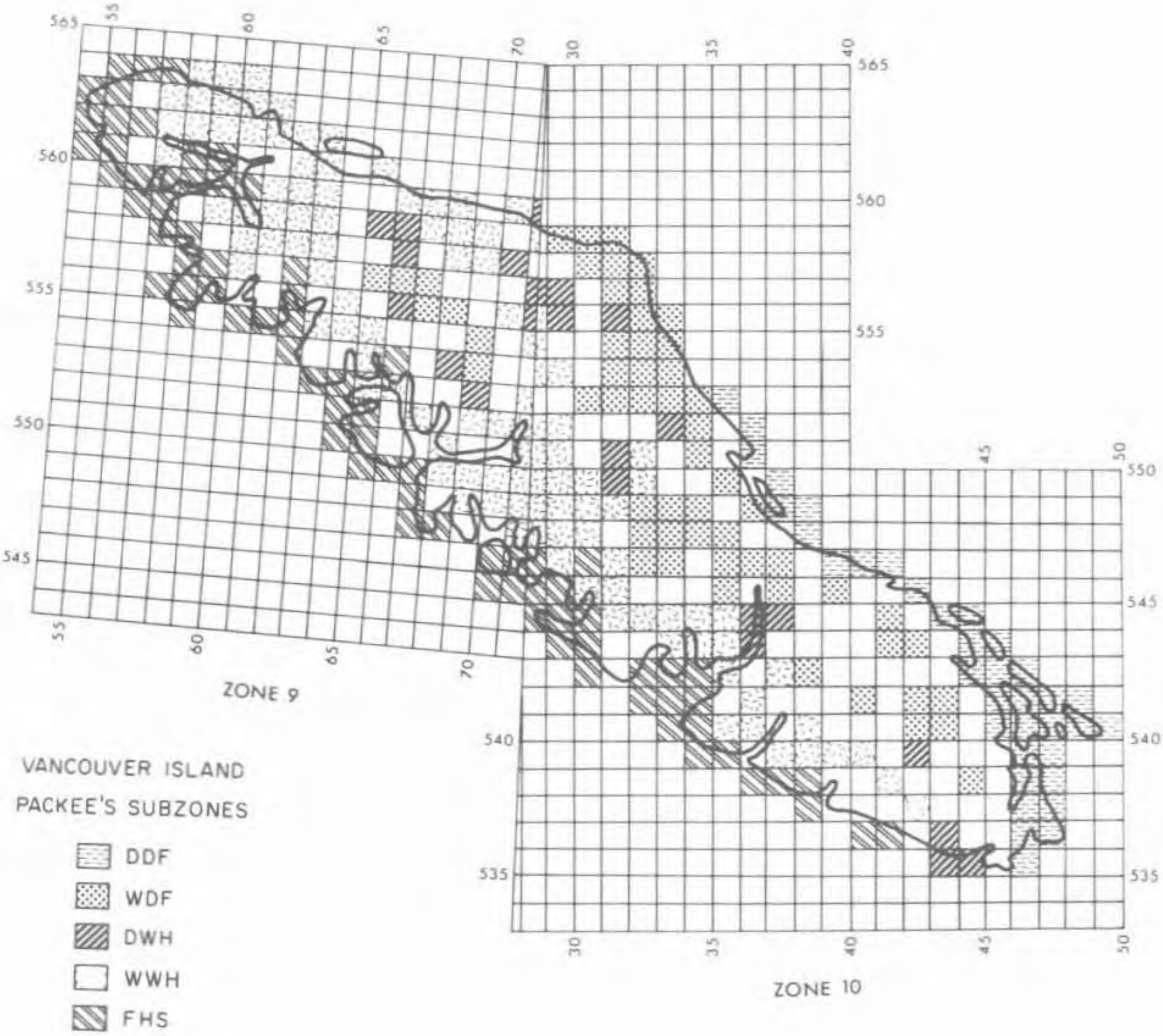

Figure 14 - Vancouver Island divided into subzones according to Packee (1972), using U.T.M. grid system. Blank squares are where more than one subzone occurs and so are unassignable to a single subzone.

Climatic Data

Climate in general, and local weather in particular, is known to affect pest populations, and one should theoretically be able to relate them to each other. Although weather records have not been taken to specifically correspond to F.I.D.S. sampling, data have been and are being collected in British Columbia and the Yukon by the Atmospheric Environment Service (A.E.S.) at many stations. While conditions at these stations will not be identical to those in the forest at the sampling points, there should be similar trends. In some cases, weather data may be associated with an increase or decrease in pest populations resulting from some unusual conditions affecting pest or host.

Weather stations are chosen principally on the basis of their apparent ability to reflect conditions affecting pest populations, but completeness and reliability of data are also important. Daily records are available from the A.E.S. in various publications and on computer tape. The weather elements observed on most days at the major stations include temperature, relative humidity, rainfall, snowfall and wind.

Programs to extract and summarize data were developed. A sample listing is given in Figure 15. Weather records summarized by 5-day and/or monthly periods are: 1) extreme and average minimum, maximum and mean daily temperatures; 2) cumulated "degree days", with temperature above 42°F each day; 3) deviation of minimum, maximum and mean daily temperatures from their long-term averages; 4) total precipitation; 5) number of days of rain; 6) the % deviation of total precipitation from the long-term average of precipitation totals; 7) the number of days in which the minimum and maximum daily temperatures were less than or greater than specified temperatures, and 8) the maximum and minimum snow depths. Minimum, maximum and mean temperature, their deviations from long term averages and total precipitation can also be print-plotted.

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5 DAY CLIMATIC SUMMARY

1176750 REVELSTOKE YEAR = 1954

	DATE: 5 DAY PERIOD	DATE: JUL-IAN	DATE: LAST YY/MM/DD	DATE: L D	MIN TEMP: THIS EXT.	MIN TEMP: HIST AVG	MIN TEMP: DEV	MIN TEMP: NO. DAYS	MEAN TEMP: AVG MEAN	MEAN TEMP: HIST AVG	MEAN TEMP: DEV	MEAN TEMP: NO. DAYS	MAX TEMP: THIS EXT.	MAX TEMP: HIST AVG	MAX TEMP: DEV	MAX TEMP: NO. DAYS	DEG DYS	PRECIP: 5 DAY TOTAL	PRECIP: DATA DAYS	PRECIP: DAYS > .1	DAYS OF RAIN
	51	255	09/12		45	45	0	5	57	58	-1	5	74	71	3	5	2186	.04	5		2
	52	260	17		46	44	2	5	56	56	0	5	69	68	1	5	2258	.21	5	1	3
	53	265	22		44	43	1	5	53	54	-1	5	66	64	2	5	2317	1.16	5	3	3
	54	270	27		44	43	1	5	58	52	6	5	74	62	12	5	2398	.01	5		
	55	275	10/02	-	28	41	-13	5	42	50	-8	5	61	59	2	5	2406	.02	5		1
	56	280	07		22	39	-17	5	38	47	-9	5	52	55	-3	5	2407	.06	5		1
	57	285	12		38	39	-1	5	47	45	2	5	59	52	7	5	2436	1.86	5	4	4
	58	290	17		34	37	-3	5	44	44	0	5	57	51	6	5	2449	.61	5	1	3
	59	295	22		31	36	-5	5	44	42	2	5	55	48	7	5	2463	.43	5	2	2
	60	300	27		25	35	-10	5	35	40	-5	5	50	46	4	5	2464	.11	5		2
	61	305	11/01	-	29	35	-6	5	36	40	-4	5	47	45	2	5	2464	.01	5		1
	62	310	06		32	31	1	5	37	36	1	5	49	41	8	5	2465	1.38	5	2	2
	63	315	11		29	32	-3	5	39	35	4	5	47	40	7	5	2465	.56	5	2	3
	64	320	16		38	29	9	5	42	32	10	5	47	37	10	5	2467	1.37	5	5	5
	65	325	21		37	28	9	5	42	31	11	5	48	36	12	5	2471	1.28	5	3	5
	66	330	26		34	26	8	5	40	30	10	5	47	34	13	5	2473	1.73	5	3	4
	67	335	12/01	-	19	24	-5	5	32	27	5	5	42	32	10	5	2473	.48	5	1	1
	68	340	06		17	24	-7	5	27	28	-1	5	37	32	5	5	2473	.42	5	1	1
	69	345	11		28	22	6	5	32	26	6	5	37	30	7	5	2473	.78	5	2	2
	70	350	16		27	21	6	5	33	24	9	5	40	29	11	5	2473	.53	5	3	3
	71	355	21		19	19	0	5	27	23	4	5	38	27	11	5	2473	.12	5	1	
	72	360	26		26	21	5	5	30	25	5	5	38	29	9	5	2473	.67	5	3	3
	73	365	31	-	10	18	-8	5	22	22	0	5	31	26	5	5	2473	2.99	5	3	
WYEAR TOTAL								365				365				365		51.74		119	152
COUNT		73																			
MAX.					51	53	-27		68	67	-18		89	83	-15			2.99			
MIN.					-15	12	0		0	18	0		9	23	1			.00			
AVG.					30	34	-4		42	43	-1		57	53	4			.70			

5 DAY PERIOD - numbers 1-73 define each 5-day period within the year.
JULIAN - Julian calendar date of last day of each 5-day period.
YY/MM/DD - year/month/last day of each 5-day period.
LD - last 5-day period of each month.
THIS EXT. - extreme minimum or maximum temperature (°F) recorded within each 5-day period.
HIST AVG - historical average minimum, maximum or mean daily temperature (°F) for each 5-day period based on records, 1949-70.
DEV - actual deviation from the historical average temperature (°F) for each 5-day period.
NO. DAYS and DATA DAYS - number of days with data in each 5-day period.
AVG MEAN - average mean daily temperature (°F) for each 5-day period.
DEG DYS - degree days, i.e., mean temperature above 42°F each day cumulated by 5-day period.
5 DAY TOTAL - total precipitation (inches) for each 5-day period (includes trace).
DAYS>.1 - number of days in each 5-day period when precipitation exceeded 0.1 inches (includes all forms of precipitation, excludes trace).
DAYS OF RAIN - number of days in each 5-day period when rain was recorded.

Figure 15. Climatic summary. Listing of Atmospheric Environment Service weather data from a representative station by 5-day period.

Portraying Pest Data

When pest population data are made available by means of the previously described programs, they can be compared by locality and host tree species. Graphing the data involves plotting actual and/or logarithmic annual population values over time, the former method showing actual population size and the latter illustrating the rate of change. The actual figures are significant in themselves, particularly if we learn what they mean with respect to the damage they cause, but the rate of change is also of interest. For example, a change from 5 to 10 insects is a 100% increase in population and could be important; however, a change from 80 to 85 insects (6% change) would probably be insignificant. Graphed logarithmically, the rate of change may be more readily seen than when the same data are graphed arithmetically.

As examples, some graphical comparisons of pest populations and accompanying weather data are shown in Figure 16. Average annual pest population data (% positive samples and average numbers of larvae per sample) on western hemlock on part of Vancouver Island were plotted on both arithmetic and logarithmic scales. Example weather records from a typical station, Port Hardy Airport, were plotted below the pest population graphs.

Figure 16 compares several different pest species with each other. The same data could be rearranged so as to compare populations on other host species with those on western hemlock, and to compare samples from different localities.

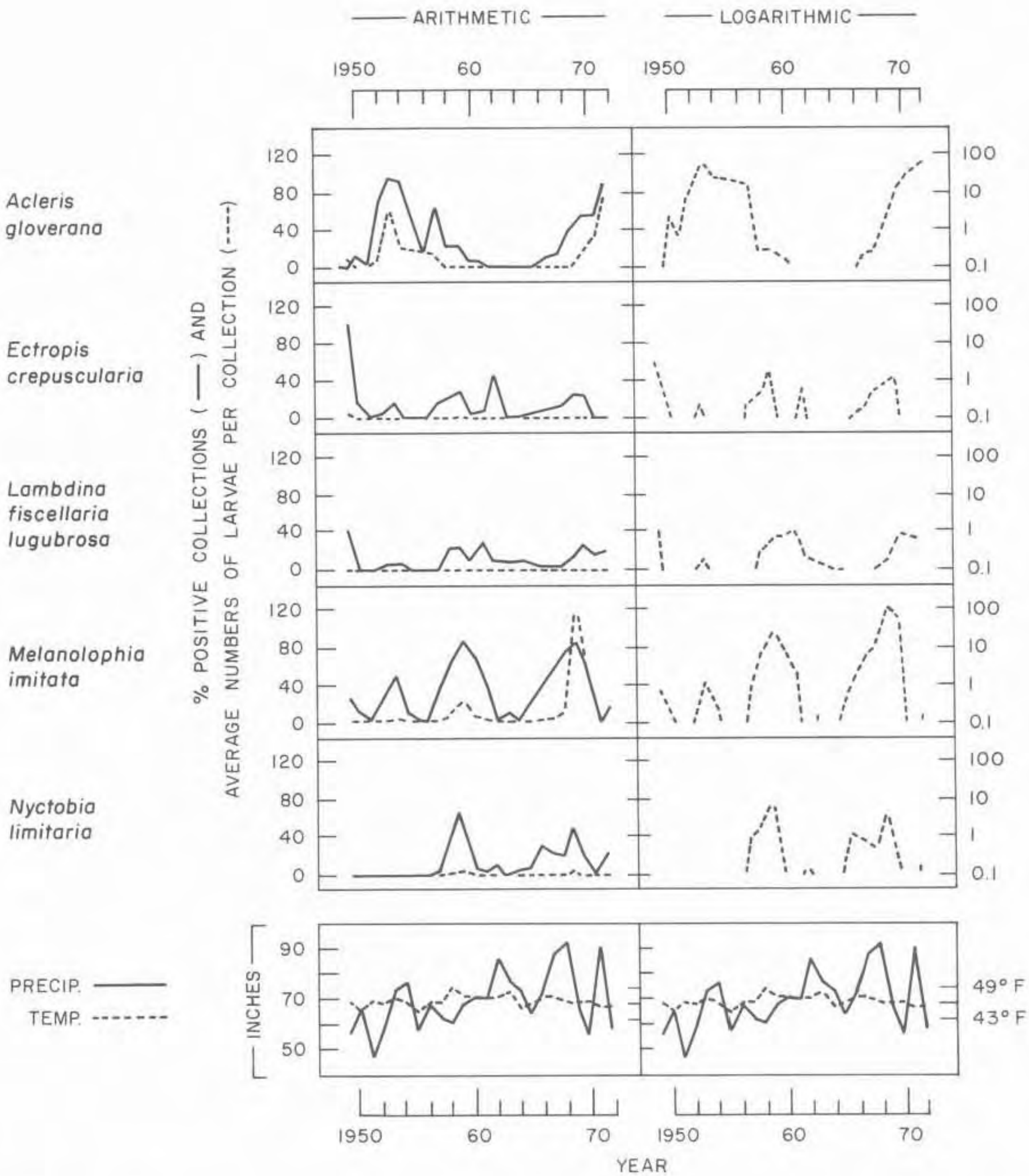

Figure 16 - Average annual pest population levels plotted on arithmetic and logarithmic scales comparing different pest species with each other. For western hemlock on Northern Vancouver Island (NVI, drainage divisions 023, 024, 025), 1949-72. Weather records plotted for Port Hardy Airport.

DISCUSSION AND CONCLUSIONS

The methods described on the foregoing pages make possible the extraction of data from the historical files of the British Columbia-Yukon Forest Insect and Disease Survey. When examined, these quantitative population records of particular insects on various tree hosts at well-defined geographic locations reveal the cyclical rise and fall of insect populations. These data, together with information on various factors affecting pest populations, such as weather, could be used to determine how observed trends might be a guide in future pest population predictions. Such observations could provide clues to the causes of population fluctuations and form the basis for future investigations.

Besides being useful historically, methods developed now should have value in collecting and interpreting future data. At present, field staff can only pass on general impressions of current populations throughout the summer because the quantitative data are only critically examined in the fall. If these data could be summarized periodically throughout the field season, we could monitor current populations as they develop. As a pest population develops, historic data can be summarized as a guide in the prediction of trends and damage.

The present system is designed for the more or less pre-planned retrieval of specific information at a central data processing location (Ottawa), with an often lengthy time interval between recognizing the need for each piece of information and its receipt. However, for timely retrieval and in-depth analysis of data, a complementary or parallel system also is being developed in the Region. And, to meet a need for instant retrieval, we are expanding the present system to an inter-active, on-line data base system.

Many questions now appear solvable. A very important one concerns future sampling intensity: whether we need more or less samples to cover forested areas to provide more and better information. Certainly some data must be collected for a measure of current populations and to detect trends. It may be, however, that fewer samples would be adequate. For example, if trends prove similar for a number of insect species, we may need only to look at a few indicator species; similarly, it may be possible to concentrate more on fewer tree species. Geographically, it might be determined from analyses of the data that sampling could be reduced, with samples confined only to areas that are most accessible and omitting samples that are now most expensive to collect. Hopefully, through such analysis of the F.I.D.S. data file, efficiency of data collection can be improved.

ACKNOWLEDGMENTS

Various Survey officers, both in Canadian Forestry Service headquarters, Ottawa, and in Victoria, contributed considerably to this study. Coordinators R.M. Prentice, C.E. Brown, A.G. Davidson and A.C. Molnar, Ottawa, provided access to historical survey files, through data analysts D.H. Johnston, R.J. McManus, and particularly R. Webster; the latter wrote most of the final programs now used to extract the required data and is working on improvements to the System. Survey technicians, in Victoria, particularly George Brown and Al Dawson in later years, assisted in the painstaking checking of data output and in formulating necessary changes.

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