Fundy Model Forest

~Partners in Sustainability~

Report Title: Monitoring Forests Pests with Pheromone Traps in the Fundy Model Forest

Author: B.A. Pendrel, R. Simpson, D. Doucette

Year of project: 1995

Principal contact information:

File Name:
Biodiversity_1995_Pendrel_Monitoring_Forests_Pests_with_Pheromone_Traps_in_the_Fundy_Model_Forest

The Fundy Model Forest…
…Partners in Sustainability

"The Fundy Model Forest (FMF) is a partnership of 38 organizations that are promoting sustainable forest management practices in the Acadian Forest region."

Atlantic Society of Fish and Wildlife Biologists
Canadian Institute of Forestry
Canadian Forest Service
City of Moncton
Conservation Council of New Brunswick
Fisheries and Oceans Canada
Indian and Northern Affairs Canada
Eel Ground First Nation
Elgin Eco Association
Elmhurst Outdoors
Environment Canada
Fawcett Lumber Company
Fundy Environmental Action Group
Fundy National Park
Greater Fundy Ecosystem Research Group
INFOR, Inc.
J.D. Irving, Limited
KC Irving Chair for Sustainable Development
Maritime College of Forest Technology
NB Department of the Environment and Local Government
NB Department of Natural Resources
NB Federation of Naturalists
New Brunswick Federation of Woodlot Owners
NB Premier's Round Table on the Environment & Economy
New Brunswick School District 2
New Brunswick School District 6
Nova Forest Alliance
Petitcodiac Sportsman's Club
Red Bank First Nation
Remsoft Inc.
Southern New Brunswick Wood Cooperative Limited
Sussex and District Chamber of Commerce
Sussex Fish and Game Association
Town of Sussex
Université de Moncton
University of NB, Fredericton - Faculty of Forestry
University of NB - Saint John Campus
Village of Petitcodiac
Washademoak Environmentalists

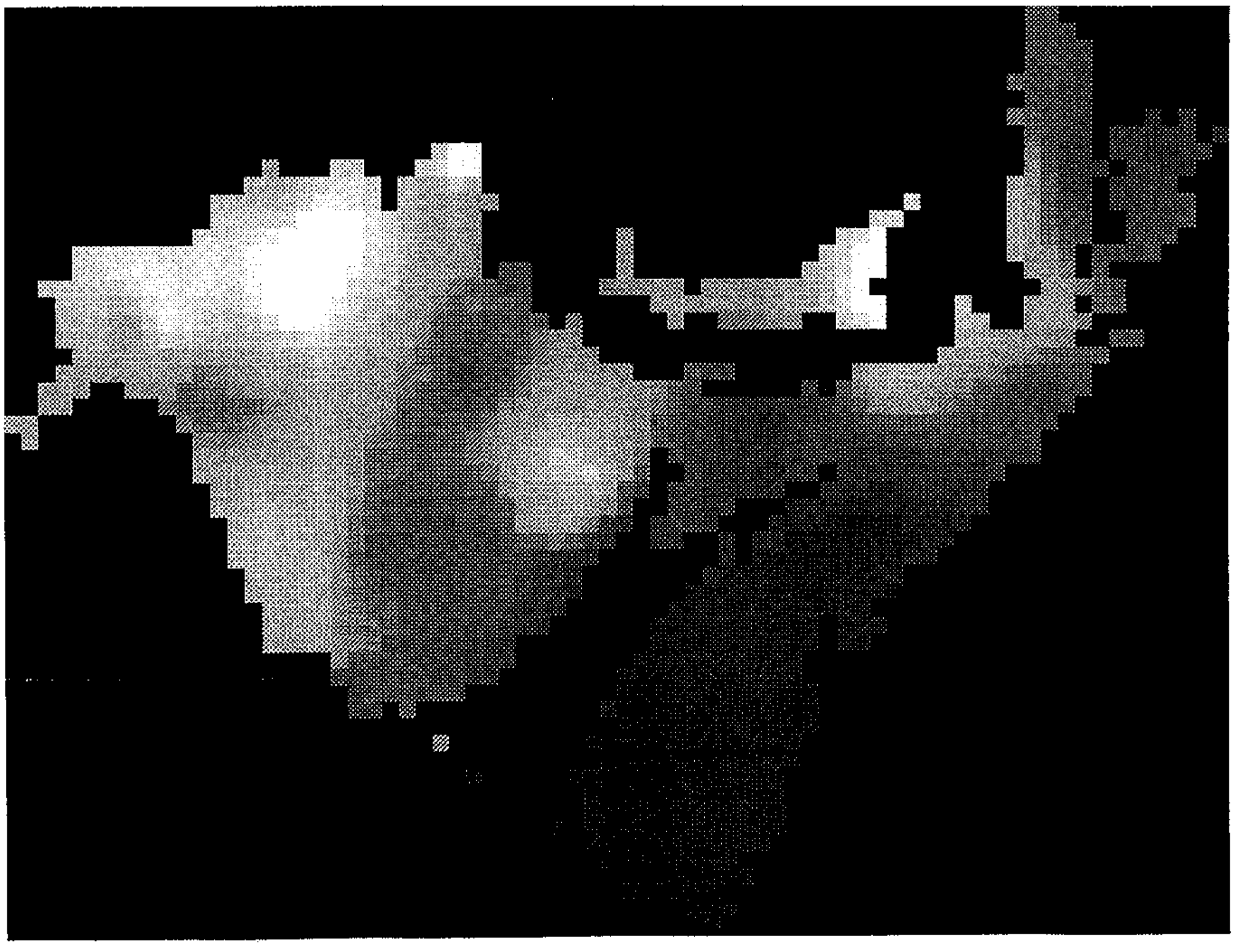
Kriged Surface 100km SPRUCE BUDWORM

C21b

Progress report for the Fundy Model Forest
Biodiversity and Landscape Dynamics Technical Committee

Monitoring forest pests with pheromone traps in the Fundy Model Forest

Prepared by B.A. Pendrel, R. Simpson
and D. Doucette



Monitoring Forest Pests with Pheromone Traps in the Fundy Model Forest

Year-end Progress Report 1994-1995

Summary

Interpolated surfaces have been created for a variety of forest pests found in the Fundy Model Forest. An interpolated surface means, essentially, that based on a selection of sites where data were collected, estimates were made for a number of other sites within a specified distance. By "filling in the blanks" between known data points a complete surface is created which can be represented as contours, or shading on a map and analyzed as a time series or in relation to other variables which might have influenced the insects populations. Surfaces created are available as GIS coverages and should provide valuable information and data for developing decision support systems and population dynamics studies.

The interpolation procedure of choice was kriging, although both an inverse distance weighting method and simple trend analysis were also investigated. Kriging is a complex and computer-intensive process which investigates the spatial behaviors of the data through an understanding of the relationship of semivariance (how the data values vary) with distance between values.

Excellent results were obtained for the spruce budworm(SBW), the hemlock looper(HLL) and the forest tent caterpillar(FTC). Obvious defoliation was not recorded in the Fundy Model Forest for any of these pests during 1994, illustrating the value the pheromone trapping approach for describing the distributions of endemic forest insect populations. Valid but less useful results were obtained for the jack pine budworm, due to the very low populations encountered, and the procedures are still under review for data from the gypsy moth.

An overlay of results for the SBW and HLL reveal remarkable mirror-like images where higher populations for one pest correspond with lower populations of the other and vice versa. The estimated FTC surface was unlike either SBW or HLL as would be expected for an aspen feeder.

To investigate another level of resolution, the Fundy Model Forest data were integrated with Maritimes regional data, allowing evaluation of the consequences of data quality (quantity and distribution) in the generation of estimated surfaces.

Introduction

This report reviews the progress made during the past year towards the development of a pheromone trapping system for the Fundy Model Forest. Examples are given of the types of graphic output being developed and major accomplishments are noted. While some technical jargon has inevitably made its way into the text, no attempt, in this interim report, has been made to produce a scientifically critical document. The reader is referred to the original proposals developed for the Fundy Model Forest and the Green Plan for more background.

A separate project for 1995-96, to establish approximately 750 monitoring sites throughout New Brunswick, has been linked to this work in the model forest, and should greatly enhance its overall impact.

Background

CFS-Maritimes Region has had a program for the development of pheromone trapping systems in monitoring and prediction of pest conditions since 1984, trapping for approximately 10 species each year. The objectives to date have been principally to determine population changes, indicating for example, a movement from endemic levels to outbreak, and to react accordingly with additional surveys or more intensive surveys. A secondary objective has been to correlate damage to the host with the numbers of moths trapped, in order to describe or predict levels of infestation (i.e. light, moderate, severe). Results are published annually in FIDS regional reports (Pendrel 1994; Magasi, 1986; 1987; 1988; 1989; 1990; 1991; 1992; 1993; 1994;) and distributed to co-operators. Predictions have been made of one pest outbreak, the forest tent caterpillar, giving 2 years warning before visible defoliation was evident. For the most part, we have not attempted to analyse our pheromone trapping data in terms of the area or volume of forest present. Computer based spatial analysis and forest inventories are required to accomplish this task.

Progress on Objectives and Deliverables

The objective of this project is to "develop and demonstrate a comprehensive pheromone monitoring system for several significant pests and covering a large and diverse management area, providing information in a form suitable for integration with the Fundy Model Forest management plan". This is expected to take 2 years. As a secondary objective, " this study will also evaluate the influences which forest composition has on pest populations as evidenced through pheromone trapping data".

Progress toward these objectives has been:

- design of a 10 X 10 km grid system throughout the model forest, placing approximately 2.5 times the number of traps as originally proposed;
- placing of pheromone traps for five species at every grid intersection (or as close as possible) and verification of location by global positioning system;
- retrieving pest tallies with associated biological data and entering all into a spreadsheet database;
- spatial analysis conducted on regional databases to gain familiarization with techniques and their applicability to the present problem;
- production of point source maps as digital and hard copy;
- interpolating the data through the procedures of kriging (other techniques were also investigated) to create computer "surfaces". This work was accomplished in part through a contract with Geodat Information Services. All work was performed at CFS using ARC/INFO/Grid software;
- collaborating with other researchers working in similar areas, principally B. Lyons and C. Sanders. Lyons was funded to spend one week in New Brunswick to discuss technology developments and put in place alternative PC-based software. This alternate system of Visual Basic/Idrisi GIS/GSLib/GeoCalc will be used in future interpolation to compare methodologies from the points of view of ease of use, accuracy, cost, etc.;
- initial analysis of surfaces to determine directions for subsequent analysis;
- involvement in a 1995-96 Spray Efficacy Research Group (SERG) proposal to extend the work of pheromone trapping and spatial analysis to a province wide level;

Scheduled for the coming year are:

- further refining and understanding of the kriging process, using the process to help define the most appropriate and efficient sampling program, calculating areas and extracting other information from kriged surfaces;
- a second year of data collection for the 3 most productive pests (SBW, HLL, GM) to create a time series and allow for GIS overlays quantifying change;
- overlays with other related variables, prediction of wood volumes affected or in the case of low pest populations determine appropriate techniques;
- final definition of a pheromone monitoring program with a discussion of advantages and disadvantages;
- investigation of means to incorporate results of this work into Fundy Model Forest planning and decision support systems development.

Results and Discussion

Data were collected for 5 forest pests, the spruce budworm (SBW), the hemlock looper (HLL), the forest tent caterpillar (FTC), the jack pine budworm (JPB) and the gypsy moth (GM) during the summer and fall of 1994. Traps were placed in a grid design at 5 km intervals except for Fundy National Park where some closer spacing was investigated. A regular grid was considered optimal for the application of geo-spatial statistics and allows for later sub-sampling of the data to simulate various operational scenarios. Due to the late flight period of the HLL and the large number of locations, the last pheromone traps were removed from the forest in December.

The Fundy Model Forest grid resulted in 299 to 165 sample points being collected, depending upon the pest. Sites were described using a GPS to 1/10 km accuracy, although all of the analyses to date have required an accuracy of no more than 1 km. Before spatial analysis all data were transformed as Ln (n+1).

Pest distribution maps of point source data were produced (Appendix 1) for initial assessment, the earliest maps being made available for the Model Forest Network meeting in Sussex, N.B. The SBW dataset was used for the most exhaustive trials, some early attempts at trend analysis (Fig 1) and inverse distance methods (Fig 2) being used to illustrate these procedures. In kriging a variety of radii were tested to define the area to be searched for data, the points used in the production of the semivariogram and thus the resulting model and interpolation of grid values. The most appropriate surfaces were selected by inspection of the variograms and interpolated maps. A variogram was required, as a minimum, to have a well defined nugget, range and sill. Inspection of the interpolated maps and comparing them with the actual trap catches which were plotted over-top, revealed false high or lows or artificial patterning predicted by some models. The final maps produced, utilized shading from green (0 moths) to red (high numbers).

Of the options available in kriging, a spherical semivariogram model was selected as has been suggested by others. Breakline data, which constrain the search for data points, was included which in the case of the FMF, simply limited interpolation beyond the Fundy coastline. A grid-cell size was selected at 1000 meters so that interpolations are done at that level and a 1 km grid cell is reflected in the final product resolution.

Various characteristics of the kriged datasets from the Fundy Model Forest are:

I. Spruce Budworm - the variogram characteristics generally improved with increase in search radius with a pattern emerging at 10 km, smoothing out by 15

Grid: tgrid5

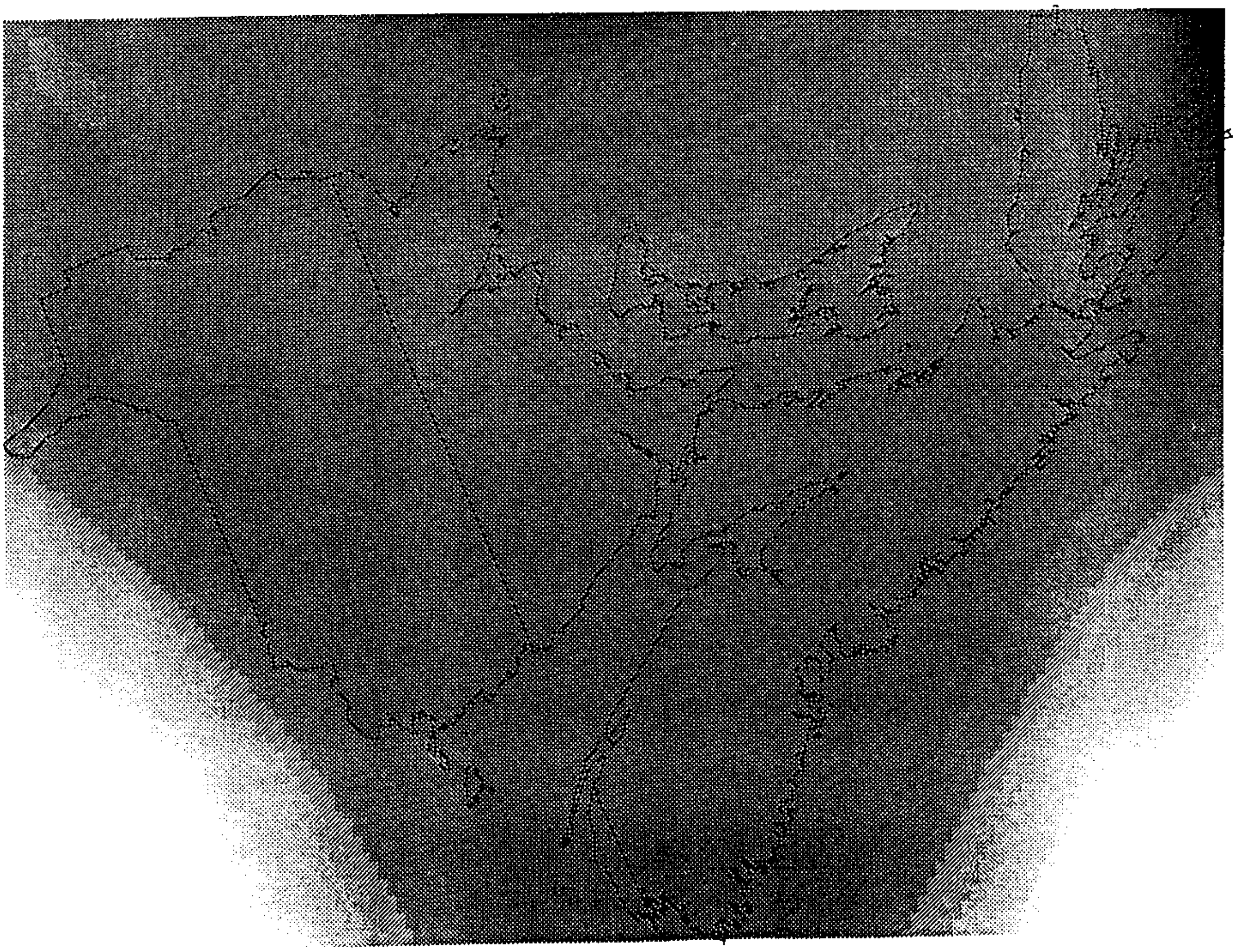


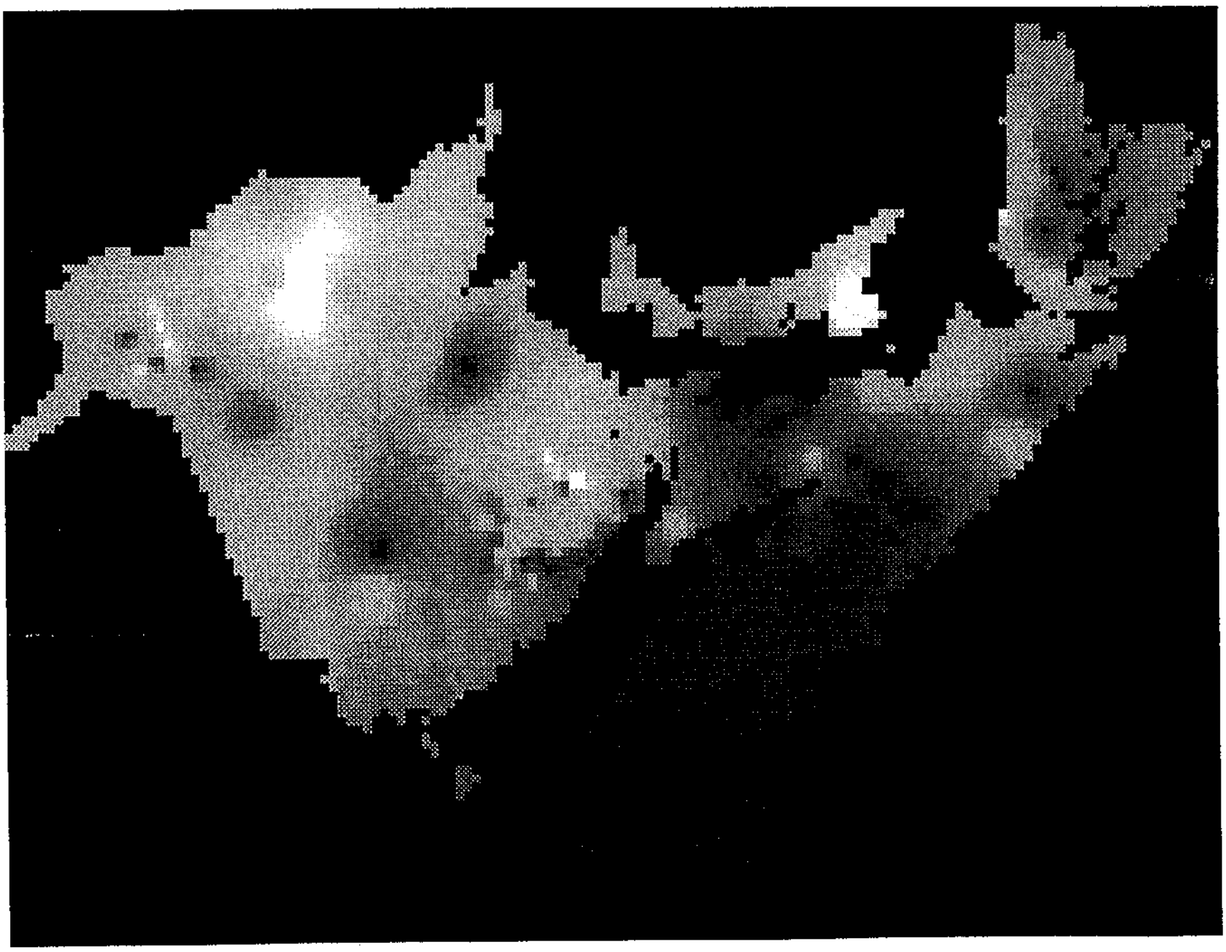
Figure 1. Example of trend analysis.

Inverse Distance Weighted Surface SBW

IGI

Max: 6

Min: 1



km and then gaining more definition at 25 km. The variogram at 10 km was poor, became more reasonable at 17.5 km and was much improved by 22.5 km. Lowest nugget and shortest range was at 25 km with increases using larger or shorter radii. Selected Radius 25 Km, Nugget 0.3, Range 22.5 km;

2. Hemlock looper - variogram characteristics generally improved with increasing search radius to 25 m. At 30 km the curve fit to the variogram did not seem appropriate, having an exceedingly short range. A manually fit curve may have been useful in this situation if this had been possible with Arc Grid. False lows appeared at radii of 10 to 20 km, while a 5 km radius tended to yield a very 'pointy' map. The best variogram yielded the most sensible map using the 25 km radius, although some higher values still seemed to be underrepresented. Selected Radius 25 km, Nugget 1.0, Range 20 km

3. Forest tent caterpillar - a range of search radius values from 5-30 km in 5 km intervals yielded a variety of different surface interpolations but no good variograms. A typical variogram shape emerged at 20 km radius but the range was very small (<5 km) and the nugget was 0. A 5 km radius preserved the negative effects of the large number of 0 catches and effectively highlighted clusters of positive traps and indeed the magnitude of their catches. A more artificial 'concentric' appearance occurred at 10 km and some high values were definitely underrepresented. A 15 km radius gave a better representation of values and took away some of the artificiality of appearance but at 20 km individual points were again highly represented (surprisingly) although between points some false interpolations appeared. At a 25 km radius both false highs and lows appeared and at 30 km the representation of higher values improved while the representation of some low values seemed weak. 30 km probably gave the most biologically sensible interpretation. Given the lack of an acceptable variogram an inverse distance weighted (IWD) methods is suggested to give a surface for use in the GIS. Selected radius 30 km, Nugget 0.42, Range not defined.

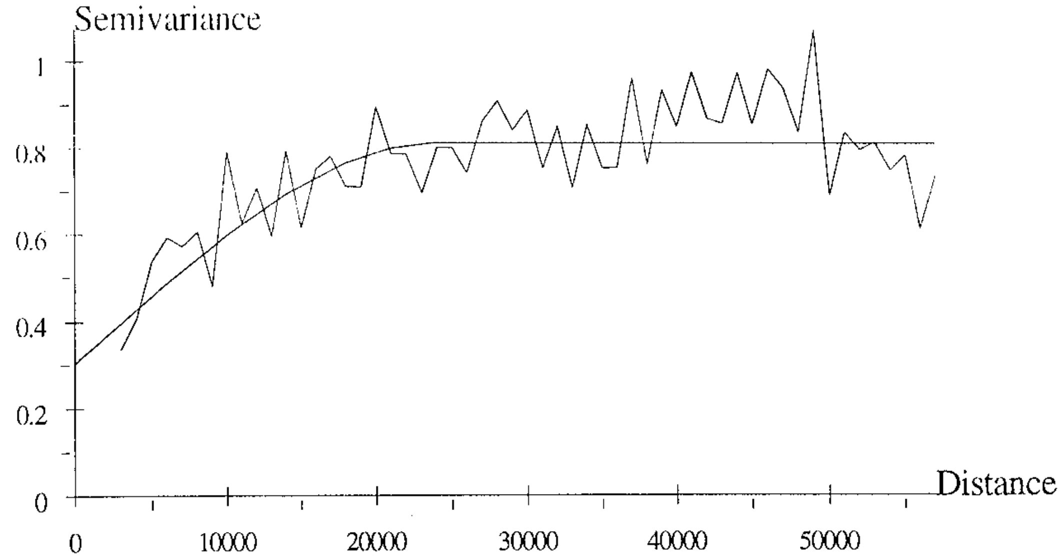
The surfaces felt to be most representative for each pest are presented in figures 3-5 respectively for the SBW, HLL, and FTC. The numbers of moths caught in SBW traps were all indicative of endemic populations as corroborated by negative L2 surveys in the same general area and the lack of obvious defoliation. Despite the low numbers, a definite pattern of SBW population is presented where coastal and some inland areas have only trace detections while a central area appears to harbor a tangible population. Interestingly, the area of higher values corresponds roughly with areas of silviculture/planting. The HLL distribution provides a striking contrast to that of the SBW in that areas of high looper numbers correspond to areas of low SBW and vice versa, giving an almost mirror image effect. Looper numbers are relatively higher than SBW

Kriged Surface SPRUCE BUDWORM 25km.

KSBW1

Max: 3

Min: 0

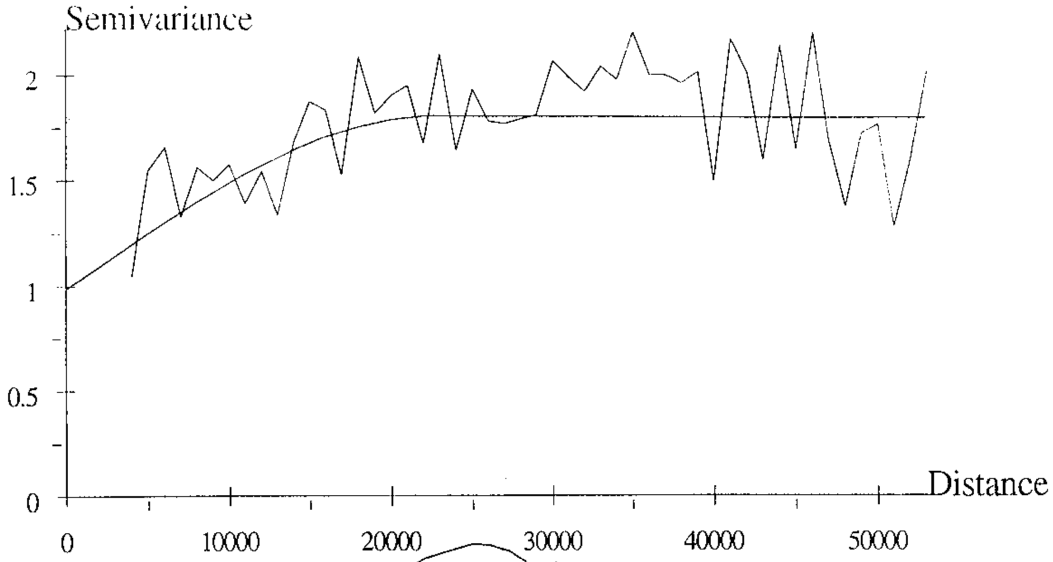


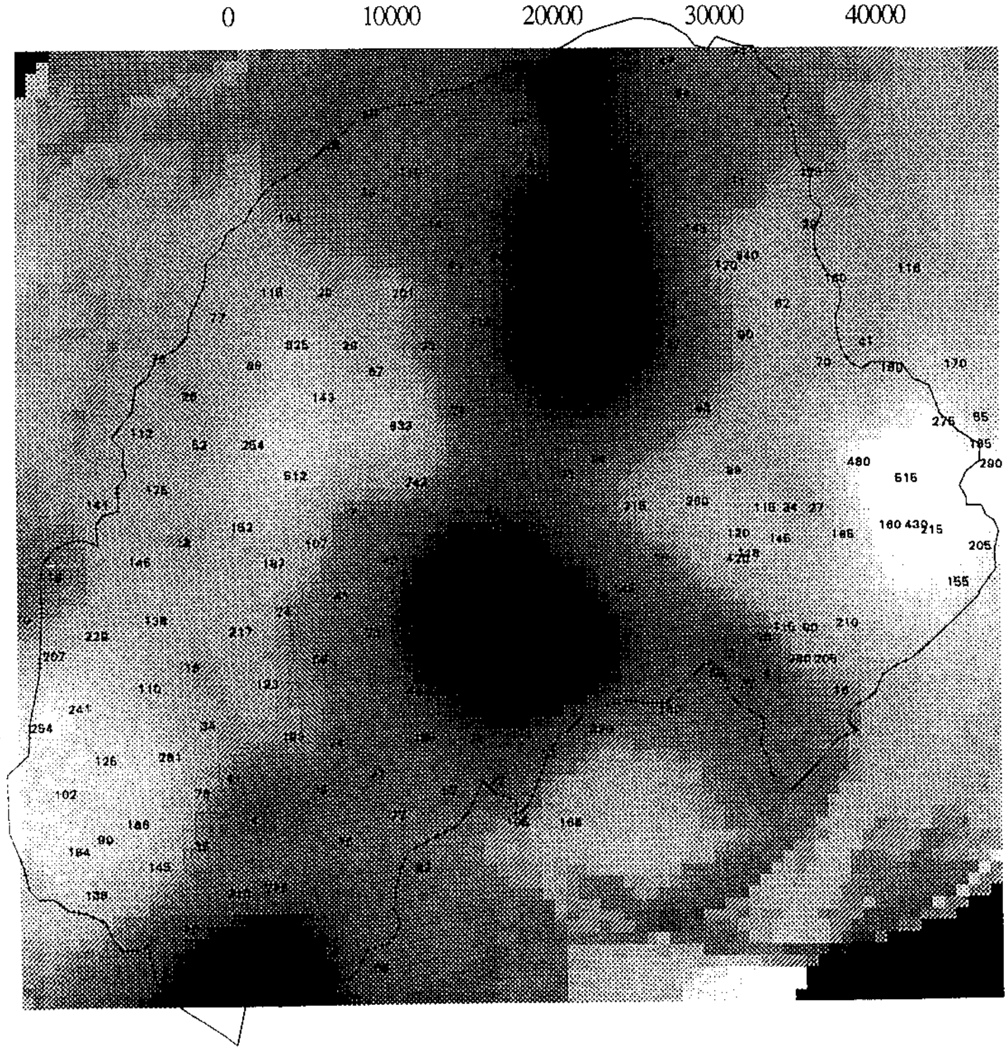
Kriged Surface HEMLOCK LOOPER 25km.

Grid: KHLL1

Max: 6

Min: 2



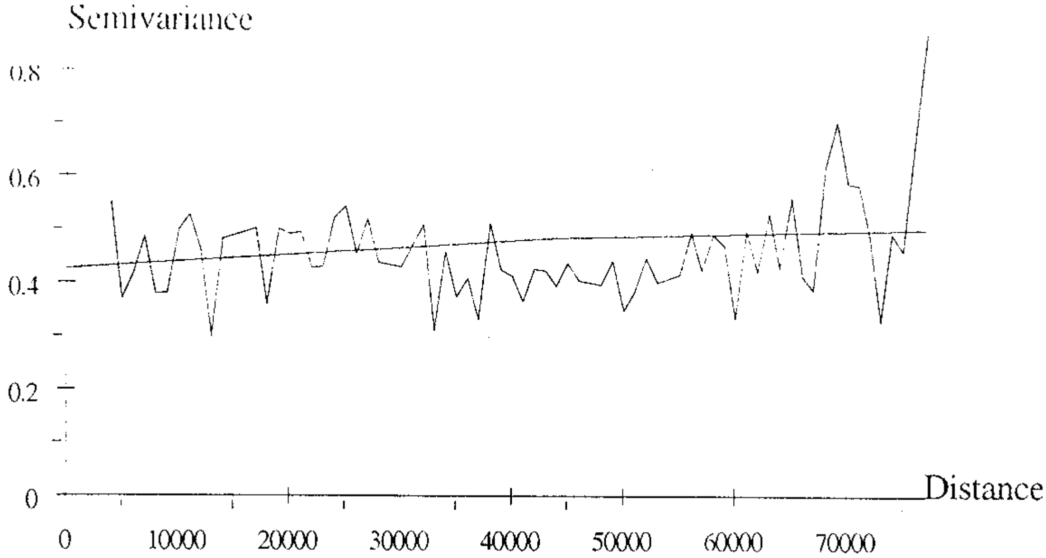


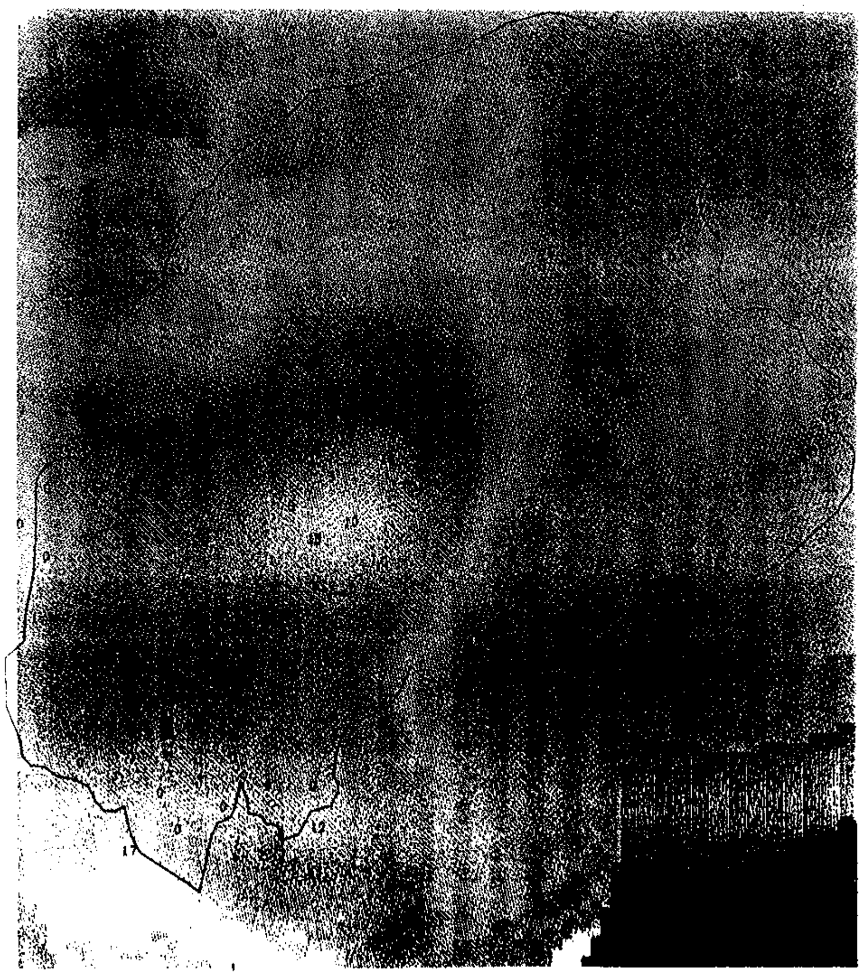
Kriged Surface 30KM FOREST TENT CATERP

Grid: KFTC2

Max: 1

Min: 0





numbers, partly due to the potency of the lure used but largely as a result of truly higher populations. Numbers are so high in Fundy National Park that it is suggested that at least light defoliation occurred there during 1994. An area of relatively high numbers along the north-west border of the model forest seems to relate to geographical features of Grand Lake and its drainage. The distribution for the FTC contrasts with the SBW and HLL in that the higher populations of FTC tend to occur where both SBW and HLL are lower. This would be as expected for an aspen feeder as opposed to softwood feeders. While the results of kriging for the jack pine budworm were valid in terms of the representations given, their usefulness is limited due to the extremely low numbers found.

Fundy Model Forest pest populations exist in the context of regional pest distributions. Spatial analysis was also therefor, carried out at a regional scale, incorporating a portion of the model forest data. This has provided for both integration of model forest data into the regional context and a comparison of the interpolated results from both the dense model forest data and sparse regional data. Such a surface for the spruce budworm is represented on the cover of this report. Figure 6 shows a kriged surface for the hemlock looper where the vicinity of the Fundy Model Forest shows the effects of having "external" data to complete estimations at the boundaries of the model forest dataset.

Future Directions

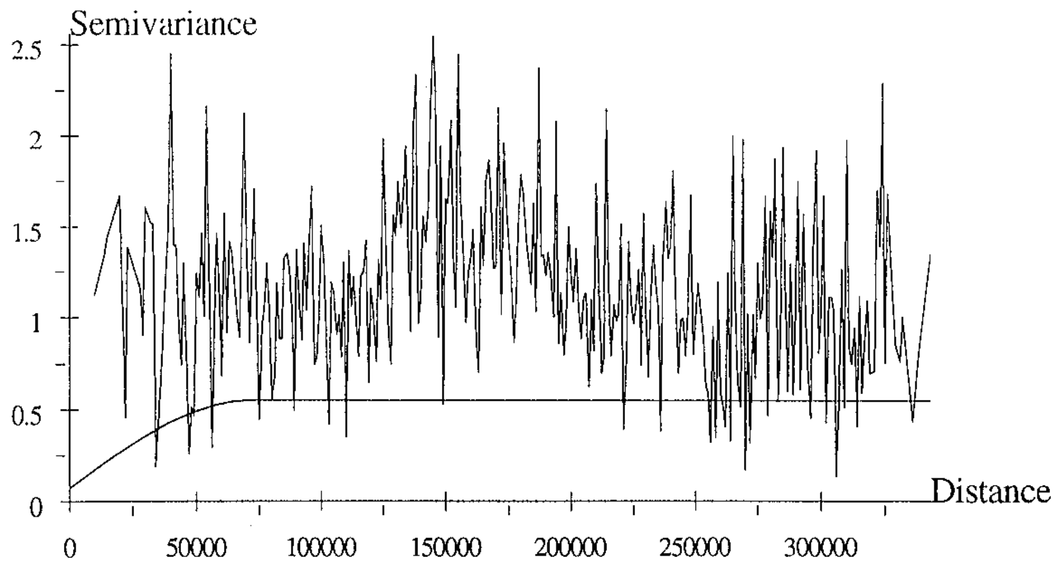
Data collection and database preparation has dominated work to date, with the greatest advances being made in spatial interpolation during the last two months leading up to the preparation of this report. In the coming year additional data is to be collected but this will be limited to 3 pests, SBW, HLL and GM. The intention of this additional collection will be to begin creation of a time series of data allowing calculation of change between years and to present additional spatial interpolation challenges for some key species. The major focus of the second year of this project however, will be to continue with the current data to further refine the interpolations and our understanding of them. This includes the use of kriged surfaces to investigate some of the relationships suggested earlier as well as to uncover new relationships which may exist. Of first consideration are the relationships of forest cover type and ecoregion with pest occurrences and an exercise to calculate wood volumes impacted.

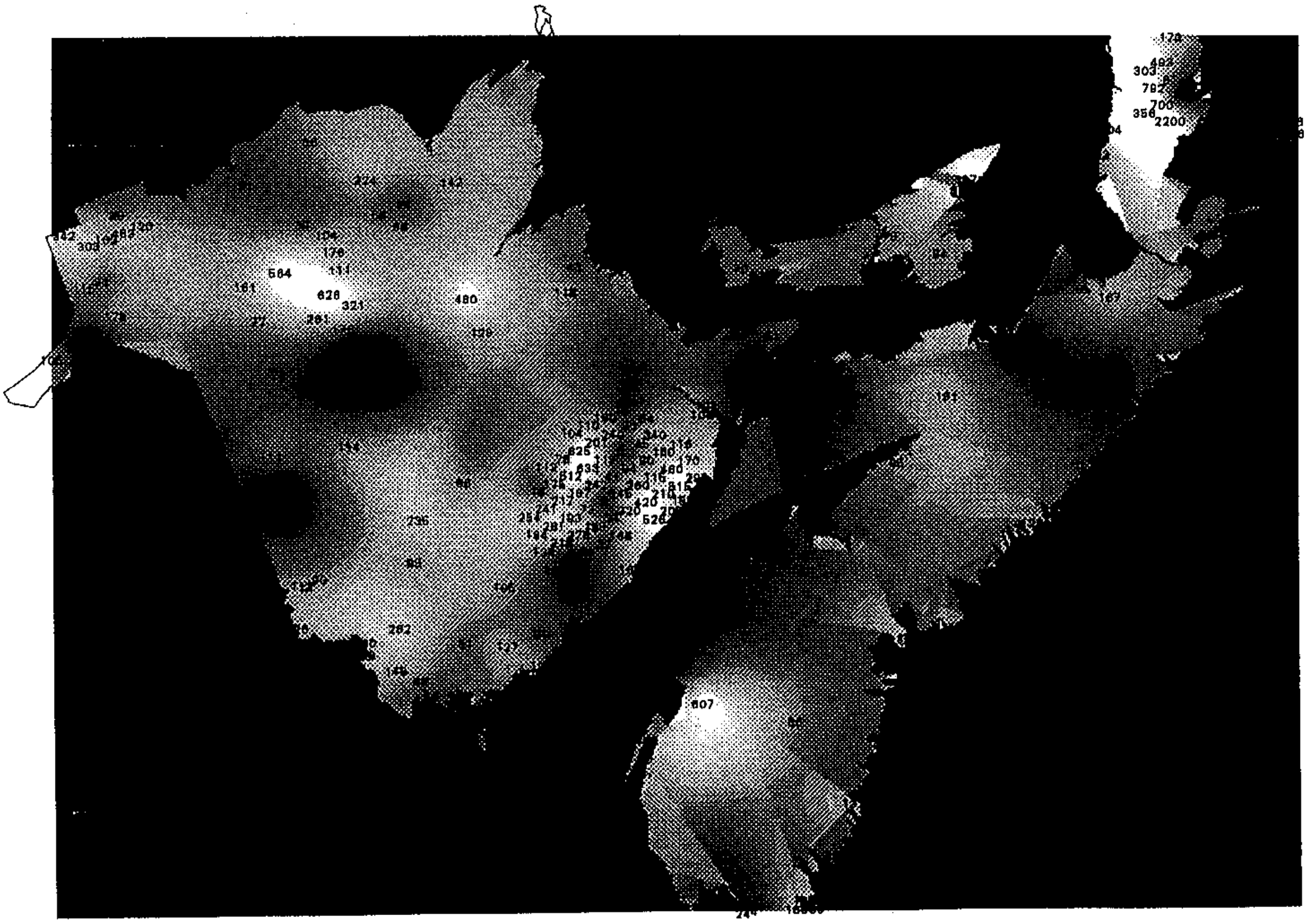
Kriged Surface HEMLOCK LOOPER 200km.

KHLLMARI

Max: 8

Min: 2





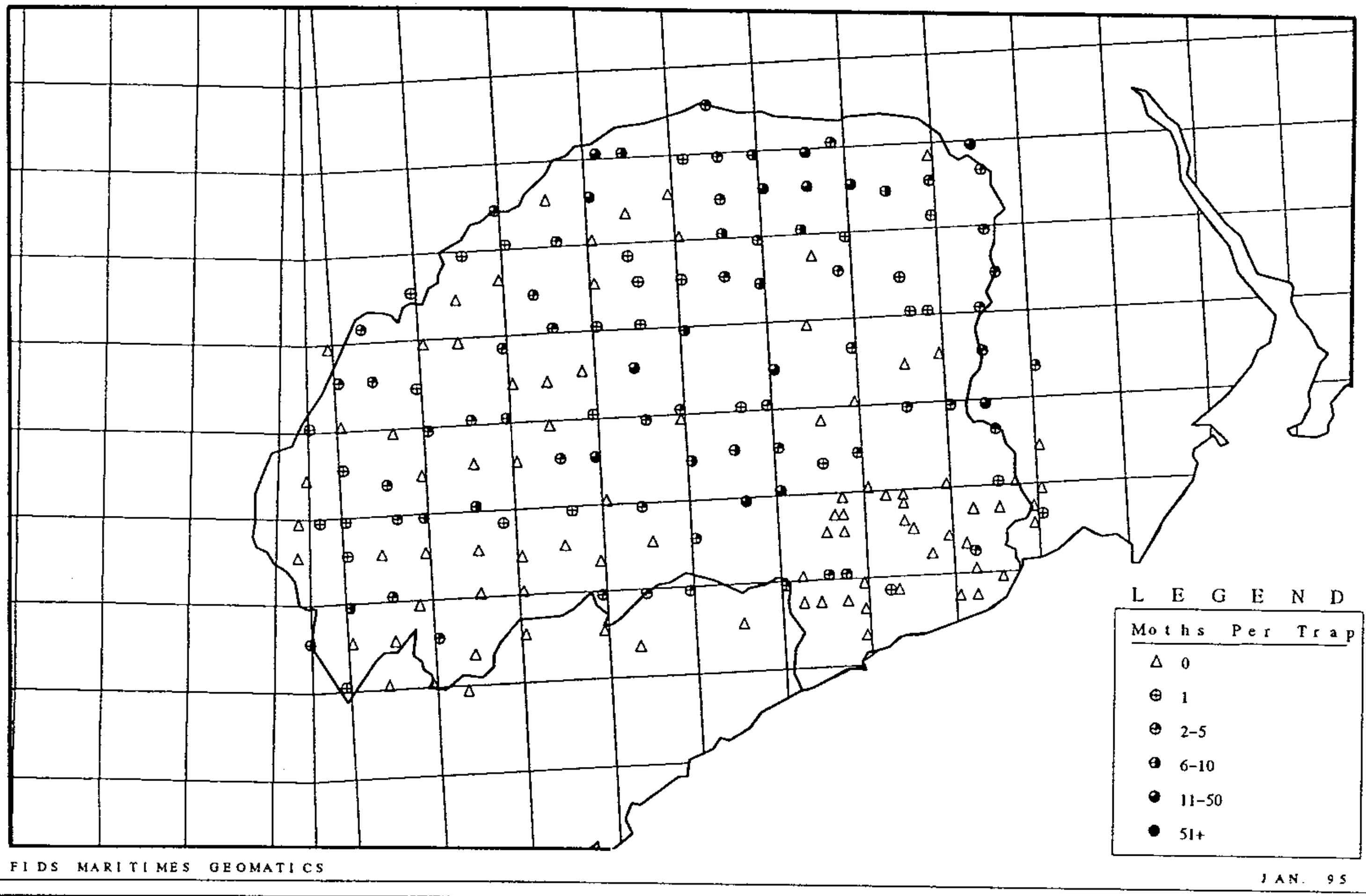
FIDS MARITIMES GEOMATICS

03 May 95 13:56:40 Wednesday

Appendix A

Examples of point distribution maps showing numbers of moths captured in the Fundy Model Forest grid.

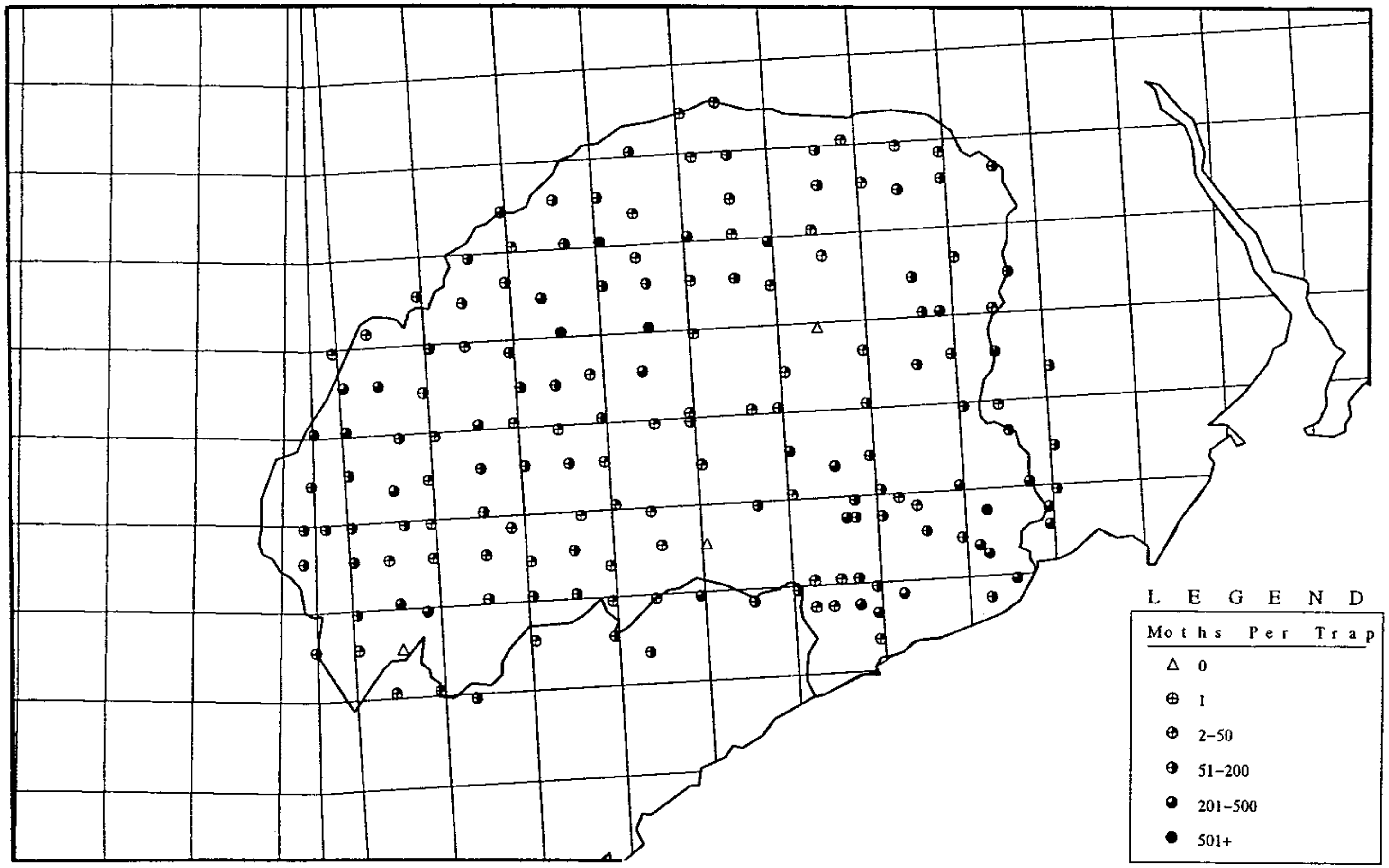
SPRUCE BUDWORM PHEROMONE SURVEY
1994
FUNDY MODEL FOREST



HEMLOCK LOOPER PHEROMONE SURVEY

1994

FUNDY MODEL FOREST



Statement of Project Accomplishments
Biodiversity and Landscape Technical Committee
November 23, 1994

Monitoring forest pests with pheromone traps in the Fundy Model Forest

Project Leader: Bruce Pendrel, Canadian Forest Service

Progress: The 5 forest pests examined were the spruce budworm, the forest tent caterpillar, the jack pine budworm, the gypsy moth and the hemlock looper. These insects all could figure prominently in management-decision making within the area of the Fundy Model Forest.

Traps were deployed on an approximated grid system involving the complete area of the FMF, with an inter-trap spacing of 5 km, down to 2.5 km in a special interest area, giving approximately 180 grid locations in the 410,000 ha Fundy Model Forest. Associated with each trap location, information on stand composition and pest damage was collected.

Traps are still being collected for two later flying species, the hemlock looper and the gypsy moth, however for the other 3 data has been computerized and initial pest distribution maps have been produced using ARC/INFO GIS. With the data collection phase nearing completion, efforts are now being turned to the spatial analysis phase of the project, which will occupy the winter of 1994-95.

Deliverables: pest distribution maps of point source data have been produced for the spruce budworm, the forest tent caterpillar and the jack pine budworm. These will be 'Kriged', a geo-statistical process yielding interpolated or "surface" maps during the next few months. The software to do this is presently being put into place, having been successfully demonstrated by one of our collaborators (B. Lyon, S.S. Marie) this month in Ottawa. Overlay with stand-level host distribution maps giving actual forested area impacted by each will then be completed and where feasible, impact maps giving the estimates wood fibre loss due to each pest. This should be done by spring 1995. Accompanying all maps will be statistics giving spatially linked data on areas and wood volumes. Decisions based on the data analysis will be made, as to the optimum or most appropriate trapping-grid intensities, host-mix selections and impact factors to be recommended for future methodology.

Background: A system for the collection and analysis of data from pheromone trapping of forest insect pests is being developed as a "model" approach to the use pheromones in monitoring pests in a large and diverse management area, the

Model Forest, providing information in a form which may be a suitable for integration in a management plan.

For the most part, we have not attempted to analyse our pheromone trapping data in terms of the area or volume of forest present. Computer based spatial analysis and forest inventories are required to accomplish this task.

As a secondary objective, this study will also evaluate the influences which forest composition has on pest populations as evidenced through pheromone trapping data. Species mixes which contain the host species but may be resistant to developing pest populations will be identified and characterised.

Proposed: In 95/96 field testing will be repeated for only 3 pests, those which are yielding the most valuable information; the spruce budworm, the gypsy moth and the hemlock looper. The original grid design will be preserved, locating traps in the exact stands as in 1994, however trap density and distribution outside of the model forest may be adjusted pending results of analysis of 1994 data. We hope to replicate the relationships between topography and cover type using the 1994 field design, modified as required. Development of methods to use multi-year data in impact estimation. Feasibility and implementation of pheromone results into decision support system for pest impacts.

This project was financially supported by the Fundy Model Forest at the level of 16% of funding. In addition to 5K FMF funding, the following resources were secured:

Green Plan IFPM	9.5K
Green Plan DSS	9.0K
Ag Canada	1.0K (in kind)
Can. For. Serv.	8.0K
Total	27.0K & FMF 5K = 32.0K

FMF funding was critical to successfully acquiring the additional resources.