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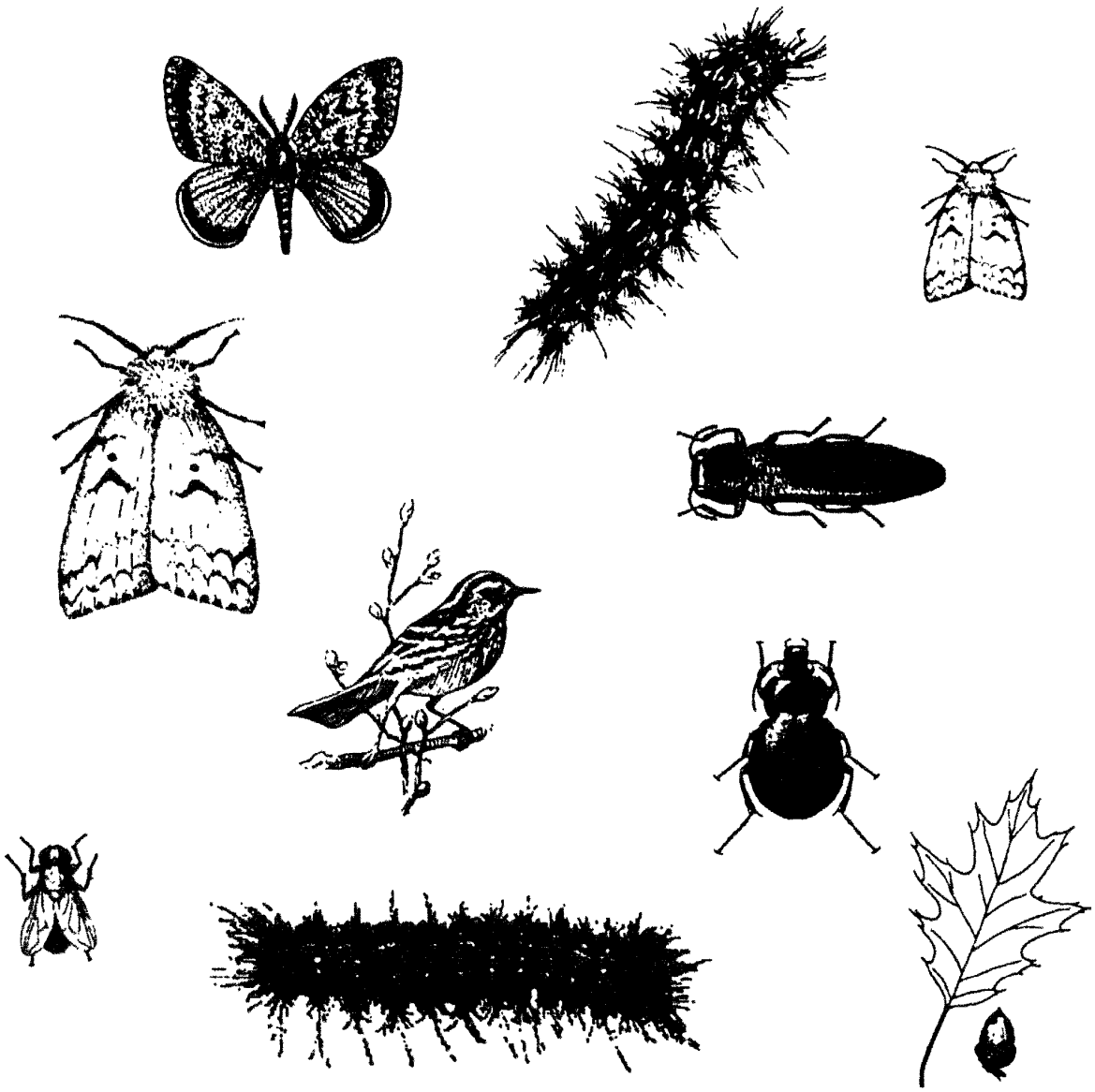

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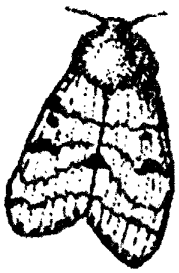

January 22-25, 1990
East Windsor, CT

Edited by
Kurt W. Gottschalk, Mark J. Twery, and Shirley I. Smith

Sponsored by:

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Forest Service State and Private Forestry

Agricultural Research Service

Animal and Plant Health Inspection Service

Cooperative State Research Service

FOREWORD

In July of 1989 representatives of Forest Service-Research (FS-R), Animal and Plant Health Inspection Service (APHIS), and Agricultural Research Service (ARS) began regular meetings to discuss opportunities for improving cooperation among the agencies conducting research on gypsy moth. Representatives from the Cooperative State Research Service (CSRS) and Forest Service-State & Private Forestry (FS-S&PF) were added over the next few months. The group is known as the USDA Gypsy Moth Research and Development Coordinating Group and has the following objectives:

a. To monitor the progress of Service programs and any breakthroughs which may influence USDA policies;

b. To keep the Services and the Gypsy Moth Working Group appraised of progress in research and methods development;

c. To identify research and methods development issues and concerns;

d. To set priorities;

e. To maximize use of current resources as well as to provide appropriate rationale to justify increased resources.

The Coordinating Group resolved at its initial meeting that a combined interagency review of gypsy moth research and development activities would add immeasurably to better communication as well as provide a comprehensive overview of ongoing research. Members of the Coordinating Group also agreed that a proceedings should be published following the meeting.

These proceedings document the efforts of many individuals: those who made the meeting possible, those who made presentations, and those who compiled and edited the proceedings. But more than that, the proceedings illustrate the depth and breadth of studies being supported by the agencies and it is satisfying, indeed, that all of this can be accomplished in a cooperative spirit.

USDA Gypsy Moth Research and Development Coordinating Group
R. Bram, ARS
C. Schwalbe, APHIS
R. Riley, CSRS
T. Hofacker, FS-S&PF
M. McFadden, FS-R, Chairperson

USDA Interagency Gypsy Moth Research Review
January 22-25, 1990
Ramada Inn
East Windsor, Connecticut

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KNOWLEDGE-BASED GEOGRAPHIC INFORMATION SYSTEMS ON THE MACINTOSH COMPUTER: A COMPONENT OF THE GYPSES PROJECT.

Gregory Elmes[1], Thomas Millette[1], and Charles B. Yuill[2]
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ABSTRACT

GypsES, a decision-support and expert system for the management of Gypsy Moth addresses five related research problems in a modular, computer-based project. The modules are hazard rating, monitoring, prediction, treatment decision and treatment implementation. One common component is a geographic information system designed to function intelligently. We refer to this component as an intelligent GIS, (IGIS). The IGIS is incorporated in a prototype GypsES package on a Macintosh computer. The paper discusses the issues in the design and development of IGIS with regard to the hardware and software components, the nature of intelligence in the GIS environment and typical functions that IGIS will be called upon to perform by the various modules of GypsES.

An overall conceptual design of the GypsES project has been formalized giving IGIS a fundamental position underlying all other components and requiring communication with them. An expert system shell that the GIS and applications modules is being refined to exploit the window, icons, menus and pointing device capabilities of the Macintosh computer. The public domain GIS software, GRASS, developed by the Army Corps of Engineers, is being evaluated for suitability for basic GIS capabilities on the basis of its open, modular, C-language program structure. A hypertext prototype is now available to evaluate the user interface, determine flows of information in the decision-making process, and examine alternative output formats.

The intelligent functions of a GIS can be separated into three classes: user interface, knowledge base for GIS operations and knowledge base for application specific functions. The user interface guides an inexperienced user through the most efficient use of the system according to the stated needs of the user. A GIS knowledge base is necessary to permit the use of GypsES modules without comprehensive training in GIS technology. The application-specific knowledge base is part of a domain-specific expert system, e.g. Hazard Rating.

The experience of GIS experts and cartographers will be formalized in a knowledge base to assist in 1) map design, 2) terrain feature and cartographic feature extraction, 3) geographic database maintenance and 4) spatial analysis / geographic decision support. The knowledge bases will feature natural language interfaces and a facility for the explanation of reasoning behind decisions, i.e. the logic path is traced through the production rules to permit the user to determine the acceptability of the expert system outcome.

PHENOLOGY PREDICTION COMPONENT OF GYPSES

Jesse A. Logan, Lukas P. Schaub, and F. William Ravlin
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ABSTRACT

Prediction of phenology is an important component of most pest management programs, and considerable research effort has been expended toward development of predictive tools for gypsy moth phenology. Although phenological prediction is potentially valuable for timing of spray applications (e.g. Bt, or Gypcheck) and other management activities (e.g. placement and removal of pheromone traps), we have had a difficult time effectively conceptualizing phenology prediction in GypsES. We have come to the realization that difficulties in representing phenology over a complex topographic landscape, such as is typical of many gypsy moth control areas, lies at the heart of the problem. Our current approach to phenological prediction, therefore, has two goals (1) representation of the complex landscape expression of gypsy moth phenology, and (2) reduction (or aggregation) of this complexity to a form that is useful in the management decision process. To meet these two goals, the problem of phenological representation falls into two catagories, Strategic Planning and Tactical Implementation.

Strategic Planning is the relatively static characterization of phenological attributes for a large management unit. In order to do this, it is first necessary to characterize temperature for the landscape in question. Sources of information for this characterization include, meterological weather stations, and the information in the USGS-Digital Elevation Model. From such information, it is possible to characterize (model) the thermal climate (on the order of a 30 yr. average)for a complex topography (c.f.: Russo et al., these proceedings). The thermal climate would be expressed as a 1-km grid, or at some other appropriate spatial scale. The next step is to run an appropriate phenological model for each grid cell in the management unit. Results of these simulations will be stored in rapid access, numerical form. Various specified gypsy moth management objectives, for example prediction of the maximum density of 2-nd larval instars, could then be easily determined for each grid cell. Since the phenological information is stored as a numeric data base, it would be a simple matter to change or test alternative objectives. Once management objectives have been stated, management constraints can be superimposed over these objectives. For example, the minimum difference in occurrence of a phenological event to be considered significant is constrained by tactical realities. A manager might decide that differences of less than 3 days between occurrence of the target event are not important. Such constraints provide the basis for aggregation. The convenient ability to test various combinations of management objectives and management constraints provide the capability of determining, through trial-and-error, an appropriate phenological resolution for tactical planning. The main things to be gained through Strategic Planning are: (1) reduction of a complex landscape to manageable terms (2) identification of areas (spray blocks) that can be treated as identical units with respect to management decisions such as spay application dates, pheromone trap placement, etc. (3) Improved delineation of spray blocks when phenology combined with other data layers through the IGIS capabilities of GypsES.

Tactical Implementation refers to the actual determination (prediction) of within season phenological events in order to better implement the tactical application of suppression or other management activities. The basic problem is phenological prediction that takes into account the inherent variability of seasonal weather patterns. This will require a combination of historical and predicted temperatures. Early in the season, the best predictor will be that obtained from the generalized phenological characterization that resulted from strategic planning. As the season progresses, observed temperatures can replace the 30-yr averages used in Strategic Planning, resulting in a improved target date. It would also be possible to incorporate both short and long

term seasonal temperature prediction into the model phenology predictions. All tactical applications require real-time running of the model to reflect seasonal phenological progression. Such applications will be possible **only** if the Strategic Planning procedure has resulted in a significant reduction in the complexity of landscape phenology. This capability remains an open research question!

In summary, the problem is not development of adequate phenological models for gypsy moth. In our opinion we already have good models. The real problem in phenology prediction for management application is not one of to little information, but one of too much information resulting in an information overflow. There is a pressing need for effective synthesis and aggregation of information to result in a useful management tool.

THE TREATMENT IMPLEMENTATION ADVISOR: A COMPONENT OF THE GypsES PROJECT

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ABSTRACT

The treatment implementation advisor is one of the knowledge based advisory modules of GypsES, a knowledge system environment for decision support in gypsy moth management. Its function is to provide detailed advice on intervention tactics for gypsy moth: e.g. aerial and ground application of insecticides and microbials, inundative or augmentative releases of parasitoids, mating disruption, genetic control and silvicultural management. The specific objectives of this project for 1989-1990 were as follows:

1) To design a knowlege based treatment implementation advisor.
2) To develop a prototype for early assessment by domain experts and potential users.
3) To begin linkage of the implementation advisor with the integrated tools of GypsES (GIS, DBMS, user interface, etc.).

GypsEX, a knowledge based module for aerial application of pesticides and microbials against gypsy moth (also operational as a stand-alone expert system), was refined considerably through verification efforts in June 1989 in Gettysburg, PA (with Ag-Rotors) and in August 1989 at Penn State University.

An initial knowledge engineering session in Hamden, CT, on August 1 stimulated three important suggestions: include a **treatment evaluation** section, a **tutorial** on the efficacy and safety of each major pesticide and ground vs aerial application, and **state-specific rules** layered on top of a fundamental rulebase for aerial application and other intervention methods.

GypsES research group meetings in August gave rise to the concept of the **treatment unit,** defined as an area within a management or administrative unit that is homogeneous with respect to treatment implementation. For example, a management unit which borders on water may have to be divided into two or more treatment units; those near water would not be recommended for aerial application of diflubenzuron.

A prototype for GypsES developed in the hypermedium SuperCard was presented in Providence, RI, on October 3 to several members of the United States Forest Service. The linkage of the implementation advisor to the other knowledge based advisors and integrated tools of GypsES is currently being conceptualized and is indicated in the prototype. Two major suggestions developed from this meeting: present a mix of **tutorials** on proposed **new technology** juxtaposed with **practical heuristics similar to current practice**, and include **algorithms to handle probabilities and incomplete information** whenever appropriate and possible.

The knowledge base for treatment implementation can be divided into choice of intervention method, aerial application of pesticides/microbials, and alternatives to aerial application. The subset of the knowledge base for aerial application can be further subdivided into choice of spray material during aerial application, spray timing, spray block prioritization, calibration, and characterization. Progress is presented on the design and software implementation of each subset of the knowledge base.

MONITORING COMPONENTS OF GYPSES

Lukas P. Schaub, F. William Ravlin, Jesse A. Logan, Shelby J. Fleischer
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ABSTRACT

The manager needs tools for assistance in planning and interpreting monitoring systems. We are building a system that designs sampling programs by interpreting data about Gypsy Moth, stand condition and management objectives. The system prioritizes areas within the management unit within budgetary constraints and defines the areas to be monitored. The system proposes monitoring procedures to guarantee an effective monitoring program. These tasks are accomplished by the following modules in the GypsES system: The Egg Mass Sampling Designer (EMSD), the Pheromone Trapping System Designer (PTSD), and the Defoliation Projector (DP).

The EMSD delineates the sampling area and proposes an adequate sampling plan. Currently, the area with pheromone trap densities above the sampling threshold are recommended to be sampled for egg masses. As in the Appalachian IPM project last year, the sequential sampling plan developed by Shelby Fleischer is proposed. The EMSD presents this underlying information, provides maps of the areas to be sampled and sampling plans.

We envision improving the design of egg mass sampling by incorporating more information. This can be the moth trend between last year and this year or the egg mass density of last year. Resident calls, observations of nearby infestations, and burlap bands are valuable indications that should be incorporated. Our system keeps track of these indications and will integrate them with more quantitative estimates of gypsy moth pressure. The threshold that defines what areas need egg mass sampling should be more comprehensive by making it dependent on the risk of the sampling unit. Egg mass sampling costs should be incorporated as well. With an estimate of the influence of the sampling plan, the size of the sampling area and the accessibility of the area on the sampling costs, the EMSD will support the manager in planning egg mass sampling under the constrained budget.

The PTSD delineates the sampling area where traps should be posted and proposes the pheromone trap distribution and pheromone trap type. With similar logic as in the EMSD only areas above a certain risk deserve greater monitoring efforts. Pheromone Trapping currently is mainly used in and before leading edge situations as an early warning system. Observations of lasts years pheromone traps and if available this years egg mass density are used to estimate GM pressure. With the PTSD the manager again has the opportunity to estimate the monitoring costs and compare them to his budget constraints.

The DP produces maps of the estimated level of defoliation. The hazard component of GypsES needs defoliation projections to estimate hazard ratings. Currently we intend to incorporate the algorithms developed by Gansner, Campbell and Montgomery into the DP. We anticipate more alternatives as we search through the available information and more researchers are focussing on this central problem in Gypsy Moth management. The uncertainty involved in the projection of the defoliation has to be considered in decisions based on defoliation projections.

With the components EMSD, PTSD, and DP of the GypsES system we want to build a system that can satisfy various needs of the forest manager: a guide for less trained personnel in planning monitoring systems and flexible compilation and display of data for the expert. It is a perfect vehicle to test new research results in field situations. Implementing scientific knowledge into forest management will no doubt improve understanding and generate new research questions.

HAZARD RATING FOR GYPSY MOTH ON A MACINTOSH COMPUTER: A COMPONENT OF THE GYPSES SYSTEM

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ABSTRACT

As gypsy moth expands into a new region, the threat of damage from its infestation is increasing greatly. The potential economic damage from the pest is extensive, considerably compounding the already substantial aesthetic damage and urban nuisance problems. One way to help forest managers deal with this threat is by providing them with a computer program which can help them determine how to set priorities for their forest lands by relative risk from gypsy moth. The program being developed, called GypsES, will serve as a surrogate "expert" on gypsy moth treatment, so it is referred to as an "expert system". The hazard rating module described here is one of several components of an integrated system.

Acceptance of working definitions of basic terminology was essential for progress in development of the hazard rating module. A management unit is defined as the smallest area having uniform management objectives, and may be subject to uniform silvicultural treatment. Susceptibility is the probability that a management unit may be defoliated by gypsy moth. Vulnerability is the probability that a management unit will sustain damage if defoliated by gypsy moth. Some trees or stands may suffer repeated defoliation (high susceptibility) without serious damage (low vulnerability), while other stands may suffer severe damage (high vulnerability) with only occasional defoliation episodes (low susceptibility). Risk is the probability that damage from defoliation will affect management objectives. Hazard is the probability that the objectives for a management unit will be affected by defoliation within a specified time period.

Hazard rating incorporates information about insect populations as surrogates for predicted defoliation. In a stand-alone mode, the module will require estimates of gypsy moth populations. As a component of GypsES, population data are obtained from the monitoring and prediction module. Hazard assessment produces the probable impact on the management unit, its importance to the management objectives, and an estimate of the economic effects. These outputs are to be used in the treatment decision module of gypses or on their own by a forest manager. Data from the associated insect population monitoring/prediction module being developed concurrently will be integrated into the Hazard Rating module. Probability of infestation combined with vulnerability of a management unit will allow this module to assess the likely severity of damage with regard to the management objectives for the unit. This assessment will produce an output of probable impacts on the stand, their importance to the management objectives, an estimate of the reliability of the predictions, and an estimate of economic effects. This output will be able to be used on its own by a manager, or can be used as input data for the next module within the system, that designed to aid in treatment decision-making. Data themes to be incorporated include stand composition, elevation, soils, roads and hydrology, management compartments, and land use types, among others.