FHP TECHNOLOGY DEVELOPMENT PROJECT PROPOSAL

PROJECT STATUS: New, not previously funded

PROJECT NUMBER: R8-2000-01

TITLE: Development of an aircraft productivity and efficiency model for large scale aerial treatment progams.

SUBJECT: Insect Management, Gypsy Moth, Integrated Systems.

PROJECT OBJECTIVE: Develop a GIS based spray productivity and treatment planning function for use within GypsES decision support model.

BRIEF DESCRIPTION OF THE PROJECT:

GypsES (Gypsy Moth Expert System) is a computerized decision support system developed by the USDA Forest Service for use by natural resource managers involved in federal, state and local pest management programs. GypsES uses a geographic information system (GIS) framework for creation and analysis of complex map sets and on-screen digitizing with topographic map backdrops or aerial photography. In 1999, through the STDP program, the Canadian Forest Service phenology model, BioSIM has been added to GypsES to incorporate additional forest defoliators and to improve treatment timing.

Determining individual aircraft productivity and project production needs varies with the size of a treatment project, the size and number of treatment blocks, the development rates of the target species over large geographic areas, and the location of helispots or airports in relationship to the treatment blocks. Estimates of treatment productivity and the evaluation the capabilities of various aircraft types are needed for project planning and contracting, as well as during project implementation.

Through the use of GypsES' GIS functions and the recently added phenology model BioSIM, these needs can be addressed. In 1988, the Forest Service developed a DOS based program CASPER (Computer Assisted Spray Productivity Routine) that could evaluate productivity for an individual treatment block, provided that it was rectangular in shape. This proposed project will integrate these programs to provide the project manager with realistic estimates of various aircraft productivity, total program productivity needs, and improve efficacy in treatment block selection.

PROJECT LEADER: John Ghent - FHP, Region 8, Asheville, NC

FHP LEAD CONTACT:

John Ghent - FHP, R8, Asheville, NC
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PINCIPAL INVESTIGATORS:

Susan Thomas - Southern Research Station, Starkville, MS
Amy Onken - FHP, NA, Morgantown, WV
Jacques Regniere - Entomologist, Forest Canada, Quebec Region

JUSTIFICATION: Since 1995, GypsES has demonstrated its acceptance as a technology trasfer and application program for gypsy moth management. In 1999, through the STDP program, the Canadian Forest Service's phenology model, BioSIM was intergrated with GypsES. Currently, the FHP field offices in Morgantown, WV and Asheville, NC support users in a wide variety of Federal (FS, NPS, US Air Force, APHIS), State (VA, NC, TN, GA, AK, OH, KY, IN, WV, MI), County governments, as well as private forest management companies and aerial applicators. Although developed to provide the user with all aspects of forest pest management, GypsES primary use has been in aerial treatment. This is due to its ease of use for on screen digitizing of treatment blocks and its import and export flight data for a variety of aircraft GPS tracking and guidance programs.

Several million dollars are spent annually on aerial application programs throughout the US. Determining production needs for the contract are currently based on guesswork or historic information from other projects. These inexact estimates can often lead to over-estimating contract needs, which can increase treatment cost by contracting for larger than needed aircraft or more aircraft than needed. Or under-estimating contract needs which often leads to treatment at less than optimal timing resulting in less effective control.

The proposed project will allow the user to evaluate productivity for various type aircraft for a specific project. It will also calculate the production rates needed to accomplish a program, for all or individual treatment blocks.

URGENCY: In both Region 8 and the Northeastern Area, the need to better estimates of treatment productivity are needed. As available treatment dollars become limiting, more precise estimates of contracting needs will assist land managers in reducing contract costs. This project will also assist managers in evaluating aircraft proposed in both negotiated bid (Request for Proposals) and low-bid (Invitation for Bid) contracts. Such evaluations will reduce the problems associated with insufficent or too many aircraft. Improved timing and grouping of blocks ready to be treated will increase effectiveness of control programs and reduce needs for retreatment.

LINK TO NATIONAL FHP TECHNOLOGY DEVELOPMENT PRIORITIES:

1. Improve management of non-native invasive insects and utilize methodology to eradicate new introductions.

This proposal is designed to improve the effectiveness of gypsy moth suppression, slow the spread, and eradication projects. It incorporates technology that is application oriented and will be enhanced through integration with current decision support systems.

SCOPE OF APPLICATION: GypsES user base includes: USDA Forest Service, Forest Health Protection (Asheville, Morgantown, Pineville, Harrisonburg, Ogden, and St. Paul); USDA APHIS (Georgia, Washington, Iowa, Minnesota, West Virginia, Indiana, Illinois, and Kentucky); federal agencies (NPS, ARS and US Air Force), States (AR, TN, NC, VA, WV, OH, GA, MI, and IN), several counties in VA and MI, private companies in Canada (BioForest Technology and Forest Protection Limited), and aerial applicators (Summit Helicopter, Al's Aerial Spraying, Hadfield Aerial Spraying, Earl's Aerial Spraying, and Helicopter Applicators). These users would receive immediate benefit from the requesed enhancements.

Interest and/or requests for GypsES have been received from a variety of other government agencies and private companies that are involved in aerial application. The GypsES Development Team is negotiating with the National Agricultural Aviation Association to license a subset of the GypsES program for distribution to NAAA members for use in aerial application worldwide.

RESEARCH BASIS: The "Baltin-Amsden Formula" (1959) describes a method for estimating the cost of an aerial spray operation. In contrast to previous cost estimating methods the formula enphasized that the cost of spraying should be based on field or spray path lengths rather than on the magnitude of the area to be sprayed. Banaugh (1984) modified the Baltin-Amsten formula to account for irregularly shaped and topographically varied spray areas. He also presented two measures of the effectiveness of the delivery of an aerial spray; the spray productivity and the spray efficiency. In addition, the work presented a systematic and orderly calculation procedure for predicting the two measures. In 1988, Curbishley and Teske implemented the procedure on a PC for evaluation of individual blocks. This project expands on Banaugh's and Curbishley's work by automating the decision process within GypsES' GIS and utilizing BioSIM phenology model to assist in project and operational planning.

METHODS: The anticipated procedure will intergrate three separate computer models to arrive at the estimates of spray productivity and spray efficiency.

In order to predict time and cost elements of an aerial spray operation, specific data supplied from GypsES and the user are required. These include: application rate, tank capacity, flying speeds, hourly costs, insecticide cost, turning times, and the number and lengths of spray paths flown. In this way, the time for a spray operation may be interpreted as the sum of several distinct operations: loading time + spray time + turning time + ferrying time + travel time between blocks.

GypsES, which contains the GIS functions, will be used to determine block boundaries, determine total treatment distances, and ferry distances in relationship to established loading areas. The user may either select all blocks or individual block(s) in a specific order. This information will be used to determine total spray operation time. These data will be fed into the Baltin-Amsden formula:

$$t = 10^4 \left(\left(T_r * Q / Q_f \right) + \left(1 / v * b \right) + \left(T_w / b * L \right) + \left(2 * a * Q / V * Q_f \right) + \left(C / V * F \right) \right)$$

Where:

t	=	total aerial spray operation time (sec/ha)
T_r	=	loading time (sec)
Q	=	application rate (l/m^2)
Q_f	=	spray material applied per spray cycle (l)
v	=	spraying speed (m/s)
b	=	swath width (m)
T_w	=	turning time (sec)
L	=	spray length (m)
a	=	ferrying distance (m)
V	=	ferrying speed (m/s)
C	=	distance between spray blocks (m)
F	=	spray block area (m^2)

The productivity function would require the user to enter information about the aircraft's calibration (air speed during treatment, application rate, and swath width), ferry speed and turning time (estimated or calculated from DGPS flight data), plus loading and fueling time.

From these inputs spray productivity and spray efficiency can be determined for the entire project. Spray productivity is the area sprayed per hour and is the quotient of the area sprayed divided by the total operational time. Spray efficiency is the ratio of the actual spray-time to the total-operational-flying-time.

BioSIM will determine optimum treatment timing for all treatment blocks and group blocks based on user defined target windows (e.g. when of gypsy moth population has peaked for second instar larvae). Grouping blocks within treatment windows will provide a more realistic production need as opposed to contracting for the entire project acreage. Development rates and timing will be based on elevation, aspect and slope obtained from digital elevation models and monthly normal temperature within GypsES. For project planning or contract evaluation, BioSIM will use 30-year normal weather data. During the operational phase, treatment would be based on current weather data.

References:

Amsden, R.C. 1959. The Baltin-Amsden Formula. Agricultural Aviation. 2(3), 95.

Banaugh, R. 1984. A method for comparing cost and productivity of aerial spray delivery. USDA-Forest Service Equipment Development Center Report No. 8434-2807.

Curbishley, T.B. 1988. CASPER, Computer Assisted Spray Productivity Routine version 0.0. Continuum Dynamics, Inc. Princeton, NJ.

Ekblad, R.B., M. Teske, R. Banaugh, and J.W. Barry. 1988. Computer assisted spray productivity routine (CASPR). ASAE Paper No. AA88-009. St. Joseph, MI: ASAE.

MEASURE OF SUCCESS: Success of any product is based on its acceptance and use by its intended clients. As stated before GypsES enjoys acceptance for a large diverse user group which continues to expand. Enhancing GypsES to provide project managers with information that will reduce cost and improve efficacy of treatment will increase its acceptance by user in all aspects of aerial application. This project will provide a vehicle to transfer previously unused or under-used pest management models in an easy to use interface to an already established user group.

COOPERATORS:

Jacques Regniere, Forest Canada, Entomologist, Population Dynamics. Developer of BioSIM. Consultation on GypsES/BioSIM interface. (1 month)

Amy Onken, Forest Health Protection, Entomologist, Morgantown, WV. GypsES support and training for NA. Operational testing and technology transfer (6 months)

Robert Mickel, REMspC, Inc. Ary, Ontario. Consultant on interface design and product testing. (2 months)

John Day, Gypsy Moth Coordinator, Ohio Department of Agriculture. Operational testing and evaluation. (1 month)

Mike Massey, Gypsy Moth Coordinator, North Carolina Department of Agriculture and Consumer Service. Operational testing and evaluation. (1 month)

Jim Johnson - Gypsy Moth Coordinator, Michigan Department of Agriculture. Operational testing and evaluation. (1 month)

Gary Bierd - Helicopter Applicators, Gettysburg, PA. Product development and evaluation. (1 month)

Al Shiffer - Al's Aerial Spraying, Ovid, MI. Product development and evaluation. (1 month)

PRODUCTS: A program will be tested as a beta version in the fall/winter of 2000 using historic flight files from DGPS systems. The final product and associated documentation will be release in spring of 2001.

PUBLICATION: A user manual has been developed for the current version of GypsES. Documentation and instructions for the Productivity Model will be added to the treatment section of the user manual.

TECHNOLOGY TRANSFER: GypsES itself is also a technology transfer application. This project will take previously developed models, combine them to work together with a full functioning GIS system. The proposed enhancements will broaden the softwares use and transfer additional technologies to pest managers and to others involved in aerial application.

PROJECT DURATION: This project is projected to take two years to deliver a finished version. The majority of funding would occur in the first year, with operational testing and refinement in the second.

LONG TERM BUDGET:

FY 2000 BUDGET REQUEST

ITEM	STDP	Other Sources
Procurement		
Supplies	$ 3,000	
Contracts	$ 15,000	
Salary		
Programmer GS-12 (3 Mon)		$ 15,000 (SRS)
		$ 7,000 (Forest Canada)
Travel	$ 7,000	
	======	==========
Total	$ 25,000	$ 23,000

FY 2001 BUDGET REQUEST

ITEM	STDP	Other Sources
Procurement		
Supplies	$ 3,000	
Contracts	$ 5,000	
Salary		
Programmer GS-12 (3 Mon)		$ 5,000 (SRS)
		$ 3,000 (State Agencies)
		$ 2,000 (Forest Canada)
		$ 2,000 (Aerial Applicators)
Travel	$ 7,000	
	======	==========
Total	$ 15,000	$ 12,000

STDP PRODUCTION FUNCTION

PROJECT NUMBER: R8-2000-01

PROJECT COST:

Year	0	1	Total
STDP	$ 25,000	$ 15,000	$ 40,000
Other	$ 23,000	$ 12,000	$ 27,000
	$ 48,000	$ 27,000	$ 67,000

PROJECT OBJECTIVES:

The addition of a spray productivity function will improve the efficiency and productivity of aerial applied pesticides (insecticides and herbicides) for both planning and contracting. This program will reach a wide range of users, particularly those individuals involved in aerial application. The function will be a subset of the GypsES decision support system. This subset is directed towards aerial applicators and project managers interested in the treatment component of the current model. All developed components from this STDP will be included in the more robust GypsES Windows NT version designed for pest managers.

ASSUMPTIONS:

1) The Spray Productivity function will reduce control costs by 5 percent in aerial treatments through more efficient contracting.
2) Improvement in aerial application planning through use of GypsES, BioSIM, and improved contracting estimates will reduce retreatment on forested areas by 10 percent.
3) A similar reduction in cost can be expected for agricultural use when this technology is used.
4) Improved productivity and timing will result in increased effectiveness of treatment programs and less cost.

BACKGROUND DATA:

1) Average acreage treated for gypsy moth per year (1990-1997) is approximately 750,000 acres. (GM Digest Tracking Database)

2) Average cost of gypsy moth treatment per acre (1990-1997) is $11.00 (GM Digest Tracking Database).
3) On average, 10 percent of all treatment acreage is retreated the next year. (Historical data, VDACS 1986-1995).

QUANTITATIVE ANALYSIS

Expenditure and Output Values (EOV) without Project

Gypsy Moth Control Insecticide application cost
(Average for aircraft and insecticide)
$11.00/ac x 750,000 acres yr. $ 8,250,000

Expenditures and Output Values (EOV) With Project

1) Gypsy Moth Control

Insecticide application cost (aircraft and insecticide)
Reduce treatment cost by 5%
$10.45/ac x 675,000 ac/yr. $ 7,053,750

Benefits Attributable to Project

EOV without project - EOV with project

$8,250,000 - $ 7,053,750 $1,196,250

Benefit/Cost Ratio

$1,196,250 / ($25,000 + $23,000+ $15,000+ $12,000) 15.95:1

Benefit Attributed to STDP funds

15.95 * $24,000 $ 382,800

PNV of Project

$ 382,800 - ($25,000 + $15,000) $ 342,800

PNV of STDP

$ 342,800 - $ 24,000 $ 318,800

In addition to forestry, the smallest sector for aerial application, this project will provide greater saving agricultural users and aerial applicators.