Project Status: New

Project number: NA-1999-02

Project Title: Development of an aerial application Spray Advisor

Subject: Insect management, vegetation management.

Project Objective: Use the spray deposition model, AgDisp as the basis for an aerial spray decision-support system.

Brief Description of the Project:
The aerial application of pesticides should be efficient, economical, safe, and accountable.
Pest managers seek to optimize the pesticide deposit within the treatment area, minimize cost, and limit spray drift to non-target areas. Techniques seek to optimize pesticide use with low levels of the active ingredient to the target area to reduce spray drift while depositing required levels on the spray site to achieve application objectives. The issues surrounding these objectives are complex. They involve the aircraft's spray system, atomizers and droplet sizes, environmental conditions, aircraft vortices, evaporation, topography and vegetation, and the target pest.

Spray models have been developed to predict aerial spray deposition and drift. These models can be used to help reduce the complexity of aerial application to a more manageable level and as educational tools for aerial applicators and pest managers. This project proposes to use the enhanced AgDisp (Version 7.0) spray deposition model (near wake portion of FSCBG) as part of an aerial application decision support system. The work with AgDisp will involve developing a heuristic search method to find input parameters that result in improved results in terms of the spray deposition simulation. The goal is to develop an expert advisor whereby a user can optimize aircraft spray operations in order to improve results. In the present use of these models, a user can only guess as to how to improve results by changing inputs and running the model multiple times. In addition, the most effective use of these complex models is to incorporate technical expertise into their operation and interpretation of results.

This project will develop an expert system that assists the user in optimizing the spray operation. To use the AgDisp simulation model in its current form, a user sets up input parameters, runs the model, and receives output in terms of deposition. This project will utilize artificial intelligence (AI) technology to enable user/model interaction such that the user will be assisted in setting model parameters that lead to improvements in simulated results. This makes the use of the model more effective as an operational tool as well as an educational/training tool. In additon, the Spray Advisor will contain the ability to import/export map files, digitize spray blocks on-screen, and import/export GPS files. These latter functions of the Spray Advisor will be public domain GIS functions (GRASS) as developed for the GypsES decsion-support system for pest managers.

FHP person to lead the project: Daniel B Twardus, State and Private Forestry, NA.

Justification:
Spray deposition prediction models have been supported by Forest Service funds since 1981. Since model development began, significant progress has been made toward understanding the spray application problem, improving model functioning, and validation. However, use of the models has been almost non-existent. This has been due to the complexity of the models, steep learning curve to use them, difficulty in interpreting results, and no spatial (map) linkages. This project will focus upon the development of an integrated package: AgDisp linked to a genetic algorithm that enables user optimization of spray prediction; public domain GIS functions to enable spray block import/export; and import/export capabilities for aircraft GPS guidance and tracking flight lines. This stand-alone package will provide spray project managers, aerial applicators, and others with the capability to use the AgDisp model for spray project planning and evaluating results.

Urgency:
This project incorporates technological advances made within the GypsES decision-support system for pest management and by the Spray Drift Taskforce (a consortium of US chemical companies that manufacture pesticides). The project is important to do now while the GypsES development team is in place. Further, increased attention is being placed upon minimizing pesticide drift in aerial application projects. The EPA is envisioning the use of spray drift prediction as a regulatory tool for both forestry and agricultural applicatons.

Link to National FHP Technology Development Priorities: This project falls within the priority of developing tools and techniques to reduce the adverse impacts of insects and diseases.

Scope of Application: A successfully developed stand-alone spray advisor will have world-wide applications both as an operational tool and as an educational tool. Within North America, specific applications include Forest Service and State aerial application projects for gypsy moth, APHIS applications for exotic pest eradication such as Medfly, and in Canada for budworm aerial suppression projects.

Research Basis: Research basis for this project is two-fold. The decision-support system for AgDisp will be based upon the use of a genetic algorithm (GA). GA's are heuristic search routines (Davi91, Gold89, Holl75). The basic idea behind the genetic search strategy is to generate solutions that converge on the global maximum (i.e. the best solution in a large search space). Using AgDisp, the user is confronted with innumerable combinations of variables from which to obtain an optimal solution. The GA will assist the user in selecting optimal spray system configuration in order to satisfy mission objectives. AgDisp, a USDA Forest Service funded model is the current standard approach to the prediction of ground deposition near the aircraft flight path (Bilanin et al 89). In this project, AgDrift version 7.0 will be used which is the same model currently

used by the Spray Drift Task force in AgDrift. It includes enhancements to conserve mass, correct evaporation at small relative wind speeds, and its predictions have been validated to 800 meters, downwind.

Methods: An enhanced version of AgDisp version 7.0 (including corrections for evaporation and mass conservation) will be used for this project. A heuristic search method will be developed to find solutions that optimize spray deposit within a target area. The search method to be used will be the genetic algorithm. It is based on the notion of using a simulation of evolution (survival of the fittest) to `evolve' good solutions. The genetic algorithm search will be conducted by Don Potter (University of Georgia, AI Center)

Steps include:
-identify input parameters based upon AgDisp
-identify output values
-set-up genetic algorithm
-design search scheme
-identify and incorporate enhancement operators

Once the genetic algorithm has been developed, a user interface will be developed. This user interface will include AgDisp data entry screens as well as interactive screens to enable the user to look for optimal AgDisp settings to maximize spray deposit within the target area while minimizing drift. In addition, embedded within the Spray Advisor will be a historical solutions library module and a solutions ranking scheme. The solutions ranking schemce will be guided by a team of experts including, Milt Teske (Continuum Dynmanics), Harold Thistle (MTDC), Bob Mickle (REMSpec, formally with Environment Canada), Mark Twery (Northeast Station), and Linda Abbott(APHIS). Model linkages to GIS functions have already been developed for GypsES using public domain GRASS.

Measure of Success:
A successful Spray Advisor will be judged to include: an AgDisp simulation model that allows a user to optimize spray aircraft set-up, project operations, and environmental considerations in order to maximize within spray block deposit while minimizing drift off target. In addition, the Spray Advisor will include (from GypsES) the ability to digitize spray blocks, import/export map files and GPS files, and the ability to overlay GPS flight lines with simulated flight lines. These last functions have already been completed within GypsES-the decision-support system for pest management.

Cooperators:

John Ghent, USDA FOREST SERVICE, Region 8, FHP
Harold Thistle, USDA FOREST SERVICE, MTDC (10%)
Don Potter, University of Georgia, Artificial Intelligence Center (25%)
Milt Teske, Continuum Dynamics, Inc. Princeton, NJ (1%)

Robert Mickle, REMSpec, Inc. Ayr, Ontario, Canada (5%)
Mark Twery, USDA FOREST SERVICE, NEFES (5%)
Susan Thomas, USDA FOREST SERVICE, NEFES (15%)
Linda Abbott, USDA APHIS Riverdale, Md. (5%)

Products:
A stand-alone Spray Advisor decision-support system including, AgDisp Version 7.0, map import/export functionality including on-screen digitizing, GPS import/export functionality, and help screens.

Publications:
An NA technical report and User Manual will be produced.

Technology Transfer:
The Spray Advisor will be available as part of the GypsES decision-support system already in use by 40 state and federal agencies across the US and Canada. In addition, the stand-alone Spray Advisor, will be available for distribution as public domain software to private industry (National Agricultural Aviation Association), pest management specialists, and educators. Distribution will be coordinated with the National Technology Transfer Center, Wheeling, WV.

Project Duration:
The project is expected to be completed in FY 2000. This is two year project.

FY 1999 BUDGET REQUEST

ITEM	STDP	Other Sources
Procurement		
Supplies	$ 2,000	
Contracts	$ 6,000	
Salary		
University GA	$ 31,200	
Programmer GS-12 (3 mon)		$ 15,000 (NEFES)
	$ 21,000 (APHIS)	
	$ 7,500 (Forest Canada)	
Travel	$ 5,500	
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Total	$ 44,700	$41,000

STDP PRODUCTION FUNCTION

PROJECT NUMBER: NA-1999-

Project Cost:

Year	0	1	Total
	$ 44,700	$ 15,000	$ 59,700

Benefits:

The Spray Advisor will improve the effectiveness and accuracy of aerial applied pesticides (insecticides and herbicides) while minimizing adverse environmental impact. This program will reach a wide range of users, particularly those individuals involved in aerial application. The proposed Spray Advisor is 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 Advisor, using GypsES GPS and GIS capabilities, will reduce insecticide application by 20 percent in aerial suppression (Williams et at 1997).
2) Improvement in aerial application technology through use of GPS guidance and AgDisp prediction 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) Reduced drift will result in increased effectiveness and less impact to non-targets from drift.

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 blocks are 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 10% $9.90/ac x 675,000 ac/yr.		$ 6,682,500

Benefits Attributable to Project

EOV without project - EOV with project $8,250,000 - $6,682,500		$ 1,567,500

Benefit/Cost Ratio

$1,567,500 / (44,700 + 15,000)		26.2

Benefit Attributed to STDP funds

26.2 * $44,700	$ 1,171,140	

PNV of Project

$1,171,140 - (44,700 + 15,000)		$ 1,111,440

PNV of STDP

$ 1,111,440 - $ 44,700		$ 1,066,740

In addition to forestry, the smallest sector on aerial application, this project will provide greater saving agricultural use and provide greater protection to the environment. Other intangible benefits will come from reduced non-target impacts from drift, greater awareness of drift from an educational technology transfer tool, and more effective control from increased deposition on the intended target.

References:

Bilanin, A.J. et al. (1989). AGDISP: The aircraft spray dispersion model, code development and experimental validation. Transactions of the American Society of Agricultural Engineers 32:327-34.

Davis, L. (1991). Handbook of Genetic Algortihms, Van Nostrand Reinhold, NY.

Goldberg, D.E. (1989). Genetic Algorithms in Search of Optimization and Machine Learning, Addison-Wesley Pub. Co.

Holland, J.H. (1975). Adaptation in Natural and Artificial Systems, Ann Arbor: The University of Michigan Press.