Enclosure 3

Special Technology Development Program
Progress Report

PROJECT NUMBER: R4-2001-04

PROJECT TITLE: GypsES West: Providing phenologically based decision support for timing effective management actions.

PROJECT STATUS (choose one of the following):

Continuing (funds are being requested for the next fiscal year to continue the project) R4-2001-04

EXPECTED PROJECT DURATION (total years for project)**:** 3

ORIGINAL EXPECTED COMPLETION DATE OF THE PROJECT (fiscal year): 2003

EXPECTED COMPLETION DATE OF THE PROJECT (fiscal year): 2003

SUBJECT: Invasive Species; Models; Monitoring; Organism Biology; Population; Risk and Hazard

STATUS OF SUBJECT SPECIES: non-native noxious

PROJECT OBJECTIVES (from original application form)**:**

The goal of the technology transfer program we propose is to provide the most efficacious gypsy moth control/eradication program with the least possible non-target impacts. In order to achieve this goal, we need to meet three major objectives, each with a number of specific sub-objectives. The models and decision support tools we develop will be generally applicable to the western United States; however, they will be specifically applied in Utah. The Utah application will be used as a prototype for other western states.

(1) Validate Improved egg hatch and larval phenology models
   a. Comparison of the new phenology model to the existing model used in GypsES
   b. Characterize model predictions for western regional climate with specific application in Utah
   c. Use existing FHP field egg hatch data for model validation
   d. Conduct studies to collect data similar to existing FHP data (collected near SLC) in southern Utah

(2) Produce validated decision support tools for field application for western regional climate with specific application in Utah
   a. Interface new model with *BioSIM*
   b. Design phenologically homogeneous spray blocks
   c. Produce target event maps for effective timing of trap placement and removal
   d. Provide real-time forecasts for effective spray applications based on modeled gypsy moth phenology

(3) Evaluate probability of establishment for Utah
   a. Obtain maps of gypsy moth host species for Utah
   b. Produce probability of establishment maps
   c. Combine (a) and (b) to produce risk of establishment maps

BRIEF DESCRIPTION OF THE PROJECT:

(1) Describe primary activities for each year, summarizing key accomplishments from prior year(s), this year's activities, and objectives for future years.

For the first funding year (2001) of this project, the primary activity involved building the quantitative machinery needed to accomplish the stated objectives. These quantitative capabilities include; (1) phenology modeling tools, (2) obtaining pertinent GIS data layers and interfacing them with BioSIM, (3) obtaining the required weather data bases. Each quantitative active will be discussed briefly.

Phenological modeling tools: The modeling software we need to utilize in order to meet our objectives are the BioSIM landscape phenology modeling system and the MATLAB mathematical

language. Each of these is a powerful modeling tool in its own right. MATLAB is an extensive mathematical language that can be used for (1) rapid model development, and (2) development of mathematical subroutines for phonological analysis. By combining these two powerful model development and deployment tools, we have unparalleled power for technology transfer of insect phenology models. In order to capitalize on this potential, we need to (1) interface MATLAB models into BioSIM, and (2) extract BioSIM models to run in the MATLAB environment. These immediate goals were accomplished during a visit to Quebec City for Logan to work with Régnière. The procedure for interfacing MATLAB models into BioSIM is provided in Attachment 1. An example code that extracts the C language code of a BioSIM executable model for MATLAB applications is provided in Attachment 2.

GIS data layers. In addition to BioSIM generated maps, Digital Elevation Models (DEM), and vegetation cover type are needed to meet project objectives. DEMs are available free of charge and can be downloaded from the Internet. The procedure for doing this is listed in Attachment 3. Vegetation cover data for Utah was supplied by Dr. Thomas C. Edwards. Vegetation type data are 30m resolution for 39 vegetation types from the Utah GAP Analysis Project. The particular vegetation types of interest for this project are; aspen, oak, and maple. Statewide data layers are shown in Attachment 4.

Weather data layers. Weather data layers are of three types: (1) Normals (averages of temperature for the thirty years from 1960-1990) for all NOAA weather recording stations for an area including Utah and a surrounding buffer zone. This data layer is used to simulate typical weather for BioSIM analyses. A map of normals sites is given in Attachment 5. (2) Real-time, historical weather data for individual NOAA recording sites. These data are used to simulate particular years weather for BioSIM analysis, and are available from NCDC Summary of the DAY, CD-ROM disks purchased from EarthInfo Inc. The procedure for capture of a particular site from these disks and processing for BioSIM input is given in Attachment 6. This Attachment illustrates the synergism between MATLAB coded analysis tools (m-files for temperature processing) and BioSIM. (3) Historical Data for weather trend analysis to meet Objective 3.b and 3.c. These data are also available from the Internet, and the procedure for downloading and processing these data are given in Attachment 7.

Quantitative capabilities described above were used to meet the following research objectives during FY2001:

1. **Validate Improved egg hatch and larval phenology models:**

1.b **Characterize model predictions for western regional climate with specific application in Utah.**

The capability for meeting this objective has been met by associating the appropriate target DEM with the appropriate phenological model. Comparative predictions of the Gray vs. Sawyer model are shown in Attachment 8 for the lower Little Cottonwood canyon area (Draper DEM). Model predictions can be refined if results from validation experiments indicate it is necessary.

1.c. **Use existing FHP field egg hatch data for model validation**

We now have the capabilities to compare egg hatch dates with both the Gray and Sawyer models for locations for the historical FHP egg hatch study sites. These comparisons will be made during winter FY 2002.

1.d. **Conduct studies to collect data similar to existing FHP data (collected near SLC) in southern Utah**

This objective has been expanded to include a representation of important sites throughout the state of Utah, including southern Utah. Representative sites were selected and HOBO temperature recording devices were placed at each location. The HOBO units measure and record ambient temperature at 10-minute intervals. Storage capacity is greater than one year for the ten-minute recording interval. Approximately 24 sterile (F1-sterile) egg masses were placed at each of 13 sites. The egg masses were contained in fine mesh, stainless steel cages positioned with respect to microhabitat in one of two ways. (1) For high elevation sites where near-surface temperature will be isothermal (0EC) due to snow cover for most of the winter, 1 egg-mass cage (containing 12 egg masses) was placed near ground surface, and another was place above the anticipated snow depth. In these cases, two HOBOs were placed, one at each egg-mass cage height. Egg-mass cages were positioned at east facing aspect on the tree. (2) For lower

elevation sites where snow cover is not a major consideration, egg-mass cages were place near ground level with one north and one south aspect.

Sites were chosen to: (1) Represent a wide latitudinal/elevational range in order to increase the power of the resulting data for discriminating between the Gray and Sawyer models. (2) Several series that provide an elevational gradient. (3) High introduction probability urban locations where current trap monitoring is occurring. (4) Sites typical of habitat for sensitive native host species. A table of site location information is provided in Attachment 9.

2. **Produce validated decision support tools for field application for western regional climate with specific application in Utah:**
2.a. **Interface new model with *BioSIM.*** Fully accomplished (see above, Phenological Modeling Tools).

2.b. **Design phenologically homogeneous spray blocks.** We now have the capabilities to produce and categorize maps of predicted target events. The target event of interest for design of homogeneous spray blocks is peak density of 1st instar larval. One quad seems to be an appropriate spatial scale. Target event maps for the Draper quad (Little Cottonwood canyon compared for the Gray and Sawyer diapause and egg hatch models is given in Attachment 10. These maps were computed based on the expected event averaged over 5 generations (years) of simulated data. Maps for all areas of high potential introduction (Salt Lake City area) will be analyzed with target event maps in conjunction with rules derived by FHP collaborators. Primary constraints are (1) probability of establishment > 0.1, (2) presence of a suitable host species, (3) minimum spray block size, dependent on aircraft, etc., and (4) Maximum life expectancy of material (typically Bt) used for control. Logical mathematical between constraints and map predictions will be used to delineate preliminary spray block boundaries during FY 2002. Once protocols are established, preliminary spray block boundaries can be easily refined if necessary.

2.c. **Produce target event maps for effective timing of trap placement and removal.** Maps similar to those derived for objective 2.b will be developed, but the targeted event will be critical points (10%; 50; 90%) in the emergence curve of adult males. This information may not be particularly useful for survey proposes (where simply placing traps before possible emergence and removing them late enough to ensure sampling the full flight period), however, these maps will serve two useful purposes: (1) The will provide dates to check traps for continued validation of model predictions. (2) Information used to assist in determining whether trapped males are from areas adjacent to the trap or transported from other areas.

2.d **Provide real-time forecasts for effective spray applications based on modeled gypsy moth phenology.** Real time forecasts will be used to fine-tune spray application dates based on current weather conditions. Results from objective 2.b will provide estimates of the range of variability expected under prevailing climate. Real-time estimates will be used to update the estimate application dates resulting from 2.d. This objective is scheduled for work during the 3rd funding year (FY 2003).

3. **Evaluate probability of establishment for Utah:**
3.a. **Obtain maps of gypsy moth host species for Utah.** Fully achieved (see above, GIS Data Layers)).

3.b. **Produce probability of establishment maps.** Capabilities to meet this objective have been fully accomplished. Although, these capabilities may be further refined based on results of objective 1, the basic technology to accomplish this objective has been met and is illustrated in Attachment 11. The procedure used to produce the probability map in Attachment 11 involves several steps: (1) Generate representative weather based on 30-year normals. Weather time-series are generated for enough years to provide a reliable sample. For Fig. 11.1, a 25-year time trace was used (i.e. a 2-year time trace was replicated 25 times). (2) For each replicated weather time-series, the model is run for enough years (i.e. 20 years for Fig. 11.1) to either converge to an adaptive seasonality, or diverge to a maladaptive seasonality. An adaptive seasonality is defined as a stable ovipositional period that occurs at an appropriate time of year. In fig. 11.1, a stable peak-ovipositional the occurred before Julian date 274 (Oct 1) was considered adaptive. (3) The proportion of replicates that converged to an adaptive seasonality was computed as a probability of establishment for that particular sampled location. A response surface (either polynomial or Kriged surface) was computed from sample locations in by the standard BioSIM algorithms. This surface was then used by BioSIM to generate the probability of establishment maps.

The constraining date for peak emergence may need to be modified by a topographic (elevation , at least) algorithm to adjust for lethal fall temperatures. Additionally, G-function analysis (Fig. 11.2) indicates that, if a critical point exists, convergence to a stable fixed point, it will be *very* rapid. The inference is that 20 generations of simulations is not really needed to determine convergence. This is important information because generation of maps for large landscapes require many thousands of simulation model runs, and any reduction in required convergence generations will result in significant cost (computer time) savings. Further CPU time reduction may be possible from analysis of the mathematical properties of the G-function. This is an interesting research question with broad implications for phonological research. We will explore these theoretical questions during FY 2002.

3.c. Combine 3.a and 3.b to produce risk of establishment maps. We have the capabilities to overlay BioSIM generated maps with other data layers (see Fig. 11.1c. During FY 2002, we will develop the required geostatistical steps necessary to meet this objective. We anticipate no procedural difficulties.

Candidly describe what has worked and what hasn't worked in the project, and within reason provide explanations that might help others to understand the limitations of techniques, approaches, technologies, and practices used or tried in the project.

The application and interfacing of BioSIM with Utah specific maps and data layers has worked even better than we anticipated. By generalizing the interface protocols for linking MATLAB coded models to BioSIM, we have elevated our modeling efforts to a new plateau. We have received immediate spin-off benefits from this work for both mountain pine beetle and spruce beetle research. Conversely, by developing the capabilities to extract BioSIM models for applications in MATLAB, we have made available phenology analysis (G-functions, etc.) tools that were previously developed for other applications. These MATLAB tools will be included in user manuals for GypsES West.

Our field experiments using F1-sterile eggs need additional consideration. We are caught in a catch-22 situation, for ethical and legal reasons, we can only use sterile egg masses. We, therefore, are forced to use egg masses from a laboratory-selected strain that may or may not reflect the diapause characteristics of introduced wild types. Additional experiments are needed to quantify the diapause characteristics of the F1-sterile laboratory strain with wild egg masses, and hopefully calibrate a relationship between F1-sterile and wild moths that can be used to interpret our field results.

CHANGES TO ORIGINAL PROJECT SCOPE OR OBJECTIVES (changes that need to be made to the original proposal and reasons for the changes):

Controlled experiments comparing F1-sterile diapause characteristics to those of collected wild egg masses. Long-term (8mos.) controlled-environment experiments using wild-type egg-masses are needed that compare predictions from Gray's model to Sawyer's model under simulated Utah conditions.. D. R. Gray in Fredericton, NB, will conduct this work where quarantine facilities are available. This is a shift in focus of the validation approach in our original proposal; therefore, no additional funding beyond that originally requested will be required.

ADDITIONS TO ORIGINAL PROJECT SCOPE OR OBJECTIVES (describe additional accomplishments expected from the project)**:** Comparison of F1 sterile and wild-type expression of diapause. This work will result in the necessary comparison and validation of the Gray vs. Sawyer models using wild-type eggs (see catch 22 above).

FHP LEAD CONTACT (FHP person submitting proposal)**:**

Name	Affiliation (Office or Dept.)	Phone, E-mail, Fax
Steve Munson	FHP, Ogden Field Office	(801) 476-9728 (801) 479-1477 FAX smunson@fs.fed.us

FHP LEAD INVOLVEMENT

Role	Time Commitment
Fieldwork, Provide expertise for management decision rules	1 mo./yr

PRINCIPAL INVESTIGATOR(S) (add lines as necessary)**:**

Name	Affiliation (Office or Dept.)	Phone, E-mail, Fax
Jesse A. Logan	RMRS, Logan UT	(435) 755-3573 (435) 755-3563 FAX jalogan@fs.fed.us
David R. Gray	Canadian Forest Service, Fredericton, NB	(506) 452-3462
Jacques Regniere	Canadian Forest Service, Quebec, PQ	(418) 648-5257

PRINCIPAL INVESTIGATOR(S) INVOLVEMENT (add lines as necessary)**:**

Name	Role	Time Commitment
J. A. Logan	Synthesis, Modeling (MATLAB), Field work	3 mos./yr
D. R. Gray	Diapause model validation	1.5 mos./yr
J. Regniere	Modeling (BioSIM, GIS data bases)	1.5 mos./yr

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COOPERATORS (contributing to, but not leading, the project) (add lines as necessary)**:**

Name	Affiliation (Office or Dept.)	Phone, E-mail, Fax
Thomas Edwards	Utah State University	(435) 755 2529
Victor Mastro	USDA-APHIS	

COOPERATOR INVOLVEMENT (add lines as necessary)**:**

Name	Role	Time Commitment
Thomas Edwards	Provide GAP data base	1 week tech. Time
Victor Mastro	Provide sterile egg masses	8 hrs. Administration 20 hrs Technician

PRODUCTS AND DUE DATES (from original application form)**:** Model validation (Objectives 1(a-d) completed by Summer 2002. Map of homogeneous spray blocks: fall/winter 2002. Target event maps for trap placement and removal: spring/summer 2002. Real-time system for timing spray applications: summer 2003. Risk of introduction map: summer 2003.

STATUS OF PRODUCTS/PRESENTATIONS: (If products or presentations are not completed by the due date, explain why and indicate when the products will be completed. Indicate whether the Region/Area considers current progress on the project to be acceptable; if not, what corrective measures are planned?)

ACCOMPLISHMENTS TO DATE: See Accomplishments above. We have successfully developed the quantitative tools required to meet our products goals.

Products: First products due this (2002) fiscal year. We anticipate meeting project obligations.

Publications:

Technology Transfer: In addition to the numbered objectives in the original proposal, there is the Technology Transfer objective of providing documentation in the way of user manuals that allow application of the approaches developed in this Project to other western States. The information provided in Attachments 1,2,3,5,6,and 7 is an initial step toward meeting this objective. Attachment 7, in particular, is an example of the tutorial approach we anticipate using to accomplish effective technology transfer. We anticipate that documentation will be provid enough detail for FHP specialists with some GIS and computer training to apply the modeling and analysis tools we develop for any arbitrary geographic region.

FIRST FISCAL YEAR FUNDED: 2001

FUNDS OBLIGATED FROM BEGINNING OF PROJECT THROUGH CURRENT FISCAL YEAR: (include both monetary and in-kind, excluding FHP base funding and salaries) (extend table as needed)**:**

	Item	Requested Funding	Received Funding	Expended Funding
PREVIOUS YEAR FY 20001				
Administration	Salary	13500	14400	15400
	Overhead	5300	6000	6000
	Travel	13000	8000	7000
Procurements	Contracting			
	Equipment	2350	3000	3000
	Supplies	2250	2000	2000
YEAR TOTALS		36400	33400	33400

CURRENT YEAR FY 2002				
Administration	Salary	13,900		
	Overhead	4,450		
	Travel	13,400		
Procurements	Contracting			
	Equipment			
	Supplies	2,250		
YEAR TOTALS		**$ 34,000**.		

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FY 2003		Requested FHP STDP Funding	Other Source Funding	Source
Administration	Salary	14300		
	Overhead	4250		
	Travel	14800		
Procurements	Contracting			
	Equipment			
	Supplies	2400		
YEAR TOTALS				
PROJECT TOTALS		**$ 35,750**		

FUNDS NOT USED FROM PREVIOUS FISCAL YEAR (If there are unused funds, what is the reason for not using them? How will the project continue without these funds?)

Fiscal Year	STDP Funding Allocated	Funds Obligated	Funds Unused

EXPECTED BUDGET FOR NEXT FISCAL YEAR: (include both monetary and in-kind, excluding FHP base funding and salaries) (extend table as needed)**:**

	Item	Requested FHP STDP Funding	Other-Source Funding	Source
Administration	Salary	14300	27700	FHP, RMRS, CFS
	Overhead	4250		
	Travel	14800		
Procurements	Contracting			
	Equipment			
	Supplies	2400		
Totals		35750		

DIFFERENCE BETWEEN ORIGINAL AND AMENDED REQUESTS AND JUSTIFICATION (the difference between originally requested funds and funds needed based on changes in the budget or scope of the project. Be specific and clear about where the money will be used and by whom)**:**

STDP FUNDING NEEDED:

Total estimated additional future funding needed beyond the current fiscal year:

Estimated STDP funding needed in remaining year(s) of the project by fiscal year. Show separately the funding to be requested/provided from other sources (extend the table as necessary).

Fiscal Year	STDP Funding	Other-Source Funding	Source
2002	$ 34,000	$ 29,800	RMRS, CFS
2003	$ 35,750	$ 27,700	RMRS, CFS