Special Technology Development Program

New Project Proposal

PROJECT NUMBER R08-2002-05

PROJECT TITLE: Monitoring, quantifying and predicting red oak borer populations in the Ozark Mountains

PROJECT STATUS: New

EXPECTED PROJECT DURATION: (2 years)

EXPECTED COMPLETION DATE OF THE PROJECT: (2004)

SUBJECT (This is a hierarchical table that helps us understand our financial investment. Please indicate percentage of funding for all that apply; total percentage for numbers 1-6 should equal 100):

1. Total Suppression/Prevention Technology	%		2. Survey and Monitoring Technology	80	%
a. Total Biological Control i. Microbial % ii. Parasitoids % iii. Synthetic hormones/pheromones % iv. Other %		%	a. Advancements in Detection Technology		%
			b. Landscape Level Assessment Technology i. Data Visualization		%
b. Total Modeling i. Pesticide (Insecticide) Application % ii. Disturbance % iii. Growth and Yield % iv. Organism % v. Population % vi. Terrain %		%	c. Remote Sensing i. Aerial % ii. Hyperspectral % iii. Satellite %		%
			d. Other – monitoring and prediction of red oak borer population trends.	80	%
c. Genetic, Cultural and Silvicultural Innovations For Controlling Pest Species i. Fire % ii. Methyl Bromide Alternatives % iii. Thinning/Regeneration Techniques and other Silvicultural Guidelines % iv. Resistance, Screening, and Breeding %		%	3. Assessment Technology	20	%
			a. GIS 10% b. Spatial Analysis 10% c. Landscape Analysis % d. Decision Support % Risk and Hazard % Expert Systems %		
d. Pesticide Application (Spray) Technology i. Equipment innovations % ii. Methods and Guidelines %		%	4. Social Values	%	
			5. Technology Transfer Innovations	%	
e. Other		%	6. Other	%	

STATUS OF SUBJECT SPECIES: native

PROJECT OBJECTIVES:: To evaluate stage-specific within-tree density and survivorship of red oak borer *Enaphalodes rufulus* (Haldeman) (Coleoptera: Cerambycidae) populations. Using these beetle mortality/survivorship data we will develop models to predict outbreak trends of the current red oak borer epidemic in the Ozark Mountains and map its occurrence in relation to spatially referenced forest site, stand and oak decline hazard rating data.

BRIEF DESCRIPTION OF PROJECT:

Plots will be selected from across the Ozark-St. Francis National Forest that will incorporate an appropriate representation of existing variation in site and stand conditions and red oak borer infestation density. All infestation plots will be GPS referenced. In these plots infested oaks will be felled at intervals that coincide with significant aspects of seasonal phenology of red oak borer development and maturation. Log sections will be returned to the Forest Insect Laboratory in Fayetteville for intensive sampling and will be either reared or dissected (or both) to estimate red oak borer immature densities and mortality over time. Concurrent sampling will be conducted to designate mortality factors acting on red oak borer populatons and to estimate density of associated borers, such as white oak borer, twolined chestnut borer, and carpenterworm, whose populations may also be increasing during this epidemic.

In spring, 2003, monitoring of adult emergence will begin. Different sampling methods will be used to estimate adult populations and oviposition potential of the next generation of red oak borers. Survivorship models will be developed from analysis of the field and lab data. These spatially referenced data will be used to describe area-wide ROB populations in relation to oak decline hazard models (Oak et al 1996). These models will be used in conjunction with existing geospatial data on site and stand characteristics from the extensive Forest Service data sets as well as from the State of Arkansas' massive (1.5 terabyte) on-line geospatial warehouse (GeoStor) will be integrated to enable prediction and mapping of anticipated mortality during the 2003-2005 generations of red oak borer.

FHP LEAD CONTACT:

Name	Affiliation (Office or Dept.)	Phone, E-mail, Fax
John Nowak	Field Office, Alexandria, LA	(318) 473-7056 jnowak@fs.fed.us (318) 473-7289

FHP LEAD INVOLVEMENT:

	Coordination/technology transfer Acquisition of CIR aerial photography Locate field sites in AR	15%

PRINCIPAL INVESTIGATOR(S):

Name	Affiliation (Office or Dept.)	Phone, E-mail, Fax
Fred Stephen	Department of Entomology University of Arkansas	(501) 575-3377 fstephen@uark.edu
Fred Limp	Director, Center for Advanced Spatial Technology, Univ Arkansas	(501) 575-6159 fred@cast.uark.edu

PRINCIPAL INVESTIGATOR(S) INVOLVEMENT:

Fred Stephen	Project director	20 %
Fred Limp	Coordination of expertise for GIS base of proposal	5%

COOPERATORS:

Name	Affiliation (Office or Dept.)	Phone, E-mail, Fax

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

JUSTIFICATION: High levels of red oak mortality were first observed on the Ozark-St. Francis National Forest in 1999, when a USDA Forest Service survey estimated that severe damage (>75% mortality/decline) existed on 19,000 acres of the Pleasant Hill Ranger District, and moderate damage (50-75% mortality/decline) existed on another 24,000 acres (Starkey et 2000). Current Forest Service estimates predict greater than 1 million acres of forest in the Ozark Mountains of Arkansas and Missouri will be impacted by the end of 2001. It is estimated that more than 1 billion board feet of timber may be lost or degraded due to this pest. It is expected that extensive oak mortality will continue to occur in these infested forests, and it is predicted that significant changes in forest species composition and age structure will result. The exceptional nature of this forest disturbance event provides a unique opportunity to assess the impact the outbreak on the forest, and also to evaluate the dynamics of the red oak borer population during the epidemic. It will be the only such study that has ever been conducted on this species, which normally occurs at endemic levels.

URGENCY: We do not know what the duration of this epidemic will be. Our ability to respond to the current outbreak through appropriate planning and management is limited by our lack of understanding of the magnitude of the epidemic and the extent of tree mortality to anticipate. An anecdotal description well describes the unique nature of this event. The world's foremost expert on hardwood borers, Dr. J. D. Solomon, see e.g. (Solomon 1995), USDA Forest Service, retired, stated that he had never seen anything of this magnitude in his entire life. Given the rarity of a native insect suddenly reaching such devastating population levels it is essential to learn all that we can about the reasons for the outbreak, the probability for continued insect population growth and the distribution and scale of damage, and the causes for the eventual population decline.

NATIONAL FHP TECHNOLOGY DEVELOPMENT PRIORITY (check at least one and describe how proposed work addresses the priorities):

Priority 1: __ Priority 2: __ Priority 3: __ Priority 4: _XXX_

Our objectives directly address the STDP current national program priorities areas, 'development of techniques to quantify the impact (forest structure and function) of insects and diseases as disturbance agents in forest ecosystems' and 'to develop or improve detection, analysis, and management of pest species'. Analysis of stage specific red oak borer mortality will permit development of survivorship models that will enable prediction of the course of the current epidemic.

TECHNICAL COMMITTEE DEVELOPMENT PRIORITY (check at least one and describe how proposed work addresses the priorities):

Priority 1: __ Priority 2: __ Priority 3: __ Priority 4: __

Priority 5: _ XXX _ Priority 6: _ XXX _ Priority 7: __ Priority 8: __

We address current technical committee priorities related to 'development of predictive impact models for native insects in forest ecosystems'; plus 'development of tools to visually display realistic outcomes of insects and pathogens at the stand or landscape level'; and finally we clearly are concerned with a 'crisis situation of a current pest problem that requires immediate attention'. We anticipate that the spatially referenced data will be used to describe area-wide ROB populations in relation to oak decline hazard models. These models will be used in conjunction with field surveys and USDA Forest Service provided CIR aerial photography to enable prediction and mapping of anticipated mortality during the 2003-2005 generations of red oak borer.

SCOPE OF APPLICATION: The range of red oak borer and concomitant oak decline extends across the eastern United States from Texas and Oklahoma to Massachusetts. The current epidemic of oak mortality and epidemic red oak borer populations is centered in the Ozark-St. Francis National Forest in North Central Arkansas, but extends throughout the Ozark Plateau and includes oak through much of northern and central Arkansas and southern Missouri. The population levels of red oak borer appear to be increasing, but without an intensive and wide scale sampling effort, prediction of how long the epidemic will persist is not feasible.

RESEARCH BASIS: In the Ozark Mountains of Arkansas and Missouri a complex interaction of multiple factors has resulted in an outbreak of red oak borer, (*Enaphalodes rufulus* (Haldeman) (Coleoptera: Cerambycidae), of unprecedented magnitude. Tree mortality associated with this insect epidemic is dramatic, extensive, has resulted in death to tens of thousands of oaks (primarily red oak) thus far, and mortality may still be increasing. In comparison to many forest pest species, the knowledge base on red oak borer is limited. Some studies on general biology and life history have been published [see for example (Hay 1974, Donley and Acciavatti 1980,

Solomon 1995)], but this is an insect that has not been the subject of extensive research. This beetle is normally endemic to deciduous forests of the Eastern US and attacks oak species throughout its range (Solomon 1995). The adults are striking, large brownish beetles about an inch or more in length. The life cycle of the insect is two years with synchronous emergence of the adults occurring in odd numbered years and next expected during June and July of 2003. Adult females may lay up to 200 eggs on the bark of living oak trees. Normally larval survival is relatively low and tree mortality attributable to this species is not high although damage to oak lumber may be economically important throughout its range (Hay 1969, Donley and Acciavatti 1980). Little is known on factors influencing population dynamics, particularly in relation to how epidemics develop and collapse. We will, from sites and stands of a variable nature, collect data on red oak borer oviposition density and distribution on oaks. These data will permit comparison with previous life history parameters and enable estimation of overwintering mortality to immatures and prediction of trends in population growth.

We have conducted preliminary studies in which we measured some life stage parameters in killed trees from the Ozark-St. Francis National Forest. We examined the literature and noted that Hay (1974) examined 480 trees over 3 red oak borer generations and reported 2.5 to 3.7 average attacks per tree (with the single highest being 71). In our preliminary studies we recorded an average attack density of 245 attacks per square meter of bark. Hay (1974) also reported that the greatest number of surviving adults to emerge from one tree (of 480) was 15. Our study showed an average emergence of 19 adults emerging per square meter of bark area. These densities of attacks, and emerging adults are so dramatically higher than any published records that they suggest the most serious and visible problems from this insect outbreak are yet to be experienced.

METHODS:

We will establish plots to establish the relationship of forest site, tree age, stand, and species composition to the oak decline/red oak borer epidemic. These plots will be coincident with areas of high and low oak decline and anticipated tree mortality. Plots will be selected from across the Ouachita and Ozark-St. Francis National Forest and will incorporate an appropriate representation of existing variation in site and stand conditions and red oak borer infestation density. This variation will be determined from preliminary surveys in conjunction with USFS personnel from District Offices across the Ozarks. All plots will be GPS referenced. Forest Health Protection personnel will coordinate the location of suitable sample plots in areas of light to heavy infestations on several forest service districts on the Ouachita and Ozark-St. Francis National Forests.

Infested oaks will be felled in these plots at intervals that define the seasonal phenology of red oak borer development as estimated from existing literature. Log sections will be returned to the Forest Insect laboratory in Fayetteville for intensive sampling. During fall, winter and early spring, bark will be examined and dissected to determine density of attacks and stage-specific survivorship of oak borer immatures. During fall, 2001, tree resistance as a mortality factor to early stage red oak borer immatures will be evaluated. Additional sampling will be designed to estimate density of associated borers such as white oak borer (*Goes tigrinis*), twolined chestnut borer (*Agrilus bilineatus*), and carpenterworm (*Prionoxystus robiniae*). Apparent mortality from woodpeckers, nitidulids and other arthropods will be estimated.

Beginning in late May 2003, monitoring of adult emergence will begin. Three concurrent approaches will be used: (1) lab rearing of log sections cut in late May; (2) field-installed, on-tree emergence cages will be checked weekly; and (3) passive traps (IPM Technologies) to intercept flying adults will be erected in sampling plots and checked weekly.

Survivorship models will be developed from analysis of field and lab data. The project's predictive modeling efforts will rely on extensive existing geospatial data sets from the Forest Service and State of Arkansas. A variety of standard geostatistical methods will be utilized to correlate site, stand and oak decline hazard data with observed and predicted red oak borer population densities. These parameters will be used to model the predicted locations and extent of future mortality in 2003-2005.

MEASURES OF SUCCESS:

Standard of Success: Evaluation of mortality factors acting on within tree populations of red oak borer will result in specific models of population survivorship that will be linked to spatially explicit stand and site data. From these results prediction of red oak borer population growth will be made, and mortality factors contributing to development of the existing outbreak can be potentially be isolated.

Expected Outcomes: Mortality/survivorship models of red oak borer generation mortality during the current epidemic.

Implementation of Products/methods: The analytical methodology and protocol for the GIS based modeling will be fully documented in a manner that should permit replication in similar forest/mortality assessments. Results from this work will be used to predict the red oak borer population levels in stands. This will be used to select stands that will be included in prevention or suppression treatments.

PRODUCTS AND DUE DATES: Mortality/survivorship models of red oak borer generation mortality during the current epidemic and predictions on the course of this epidemic should be produced in 2004. All geospatial analyses will utilize Arc8.1 and extensions and map results will be fully documented with FGDC compliant metadata. All developed geospatial data will be provided in compatible map projection and geodatabase formats. Algorithm and work-flows will be fully documented using map algebra. Any VBA applications developed will be provided.

PUBLICATIONS: Publication of results will be made through appropriate scientific journals (e.g. Environmental Entomology; Journal of Agricultural and Forest Entomology; Forest Ecology and Management).

TECHNOLOGY TRANSFER: It is our intent to create a web site that deals with the biology, life history, and ecological issues associated with the outbreak and to include data from the proposed study on prediction and anticipated course of the outbreak. Scientific presentations will be made at international, national and regional meetings. A recent IUFRO meeting in France entitled "Facing a Crisis" considered the impact and response to analogous forest disturbances throughout the world. We presented a synopsis of the red oak borer situation at that meeting and outlined this disturbance in relation to other events such as sudden oak death and beech decline.

PRODUCT LEVERAGING: A proposal submitted by the Principal Investigator to the Arkansas Forest Resources Center has been funded. That project is designed to establish the relationship of forest site, tree age, stand, and species composition to the oak decline/red oak borer epidemic. These plots will be coincident with areas of high and low oak decline and anticipated tree mortality. Flight intercept traps (of a passive nature) will be used to enable relating ovipositing adult beetle densities in 2003 to the variables of site, age and stand structure will be situated in each plot. In addition a grant proposal to develop a GIS based system for quantifying, assessing and predicting impact of the oak decline and red oak borer epidemic in the Ozark Mountains, in association with Dr. Fred Limp, (cooperator in the current proposal) is in preparation. The objectives of that effort will be to develop an automated system in which historic data illustrating oak decline and red oak borer-caused tree mortality along with mapped environmental factors and satellite imagery are used to support a publicly accessible information system. That system will allow land owners, foresters and the forest products industry to easily obtain on-line maps showing where past oak decline and red oak borer mortality have occurred, the current status of oak mortality and detailed maps that indicate the potential for future oak decline and red oak borer mortality.

LONG-TERM BUDGET REQUEST:

	Item	Requested FHP STDP Funding	Other-Source Funding	Source
FY 2002				
Administration	Salary	$23,000	$35,500	UA, AFRC
	Overhead	$3,500	$11,000	UA
	Travel-UAR	$3,000		
	Travel-FHP	$4,000		
Procurements	Contracting			
	Equipment	$2,500		
	Supplies	$3,000		
YEAR TOTALS		$39,000	$46,500	

FY 2003				
Administration	Salary	$24,000	$35,500	UA, AFRC
	Overhead	$3,500	$11,000	UA
	Travel-UAR	$3,000		
	Travel-FHP	$4,000		
Procurements	Contracting			
	Equipment	$1,500		
	Supplies	$3,000		
YEAR TOTALS		$39,000	$46,500	

LONG-TERM BUDGET REQUEST EXPLANATION: Funds are requested for partial support of a graduate student and forest entomology technician to collect and process samples for estimation of red oak borer within tree mortality. Travel costs include vehicle maintenance and mileage for regular trips to field locations. Travel costs to enable presentation of results of this investigation at national and regional scientific meetings are also included. Equipment includes purchase of log splitters, chainsaws and other related oak sampling equipment. Additional salary funds are to support a GIS specialist from the Center for Advanced Spatial Technology (UA Fayetteville). Contributed costs are salaries for a forest entomology post doctoral research associate who will be instrumental in participating and helping to direct field and laboratory aspects of the project.

BENEFITS: This project would provide information on life history and biology of red oak borer populations during the course of this epidemic, including assessment of mortality factors that may influence growth and decline of beetle populations. In conjunction with our related research efforts it would also assess the overall magnitude of the red oak borer outbreak in terms of infestation area, tree mortality and borer population levels and evaluate the relationship of factors such as site, stand and species composition on distribution and intensity of borer populations. It would thus provide significant new knowledge on this previously innocuous species and provide predictions of the course of the immediate epidemic.

LITERATURE, CITATIONS, ATTACHMENTS, etc.:

Donley, D. E., and R. E. Acciavatti. 1980. Red oak borer. Forest Insect and Disease Leaflet 163, USDA Forest Service, Washington, D.C.

Hay, C. J. 1969. The life history of a red oak borer and its behavior in red, black, and scarlet oak.

Hay, C. J. 1974. Survival and mortality of red oak borer larvae on black, scarlet, and northern red oak in eastern Kentucky. Annals of the Entomological Society of America 67:981-986.

Oak, S., F. Tainter, J. Williams, and D. Starkey. 1996. Oak decline risk rating for the southeastern United States. Annales des Sciences Forestierres 53:721-730.

Solomon, J. D. 1995. Guide to insect borers in North American broadleaf trees and shrubs. in. USDA Forest Service.

Starkey, D. A., A. Mangini, F. Oliveria, S. Clarke, B. Bruce, R. Kertz, and R. Menard. 2000. Forest health evaluation of oak mortality and decline on the Ozark National Forest, 1999. 2000-02-02, USDA Forest Service, Alexandria, LA.