FHP TECHNOLOGY DEVELOPMENT PROJECT PROPOSAL

PROJECT STATUS: New, not previously funded

PROJECT NUMBER: R8 - 1999 - 02

PROJECT TITLE: Operational Field Tests of Biological Control of Southern Pine Beetle by Providing Nutritional Supplements for Native Parasitoids.

SUBJECT: Bark beetles, enhancing biological control agents, biological control, insect management, timber management

PROJECT OBJECTIVES: We will conduct limited operational field trials of our biological control technology. We will measure infestation growth in a selection of SPB (southern pine beetle) infestations treated with Eliminade-TM. Infestations will be on several different Ranger Districts in Region 8. The treatment will demonstrate on an operational basis that southern pine beetle infestation growth can be slowed or stopped by native parasitoids if they have a nutritional supplement available when they emerge. The overall project goal is to develop effective and marketable parasitoid food application protocols that complement existing SPB control strategies and can be easily transferred to District personnel.

BRIEF DESCRIPTION OF PROJECT: This project will address a major advancement in the treatment of southern pine beetle in southern yellow pines. We will use the techniques that have been developed and tested by the University of Arkansas on both private and federal lands. The goal is to operationally treat at least 50 SPB infestations in a double blind evaluation. A nutritional supplement will be added to trees in one half of the SPB infestations and the other half will be treated with a non-food placebo. The University of Arkansas will compare the abundance of SPB and their parasitoid populations within some of the treated infestations and post-treatment infestation growth in the treated infestations to determine how effective the treatment is in operational situations.

FHP PERSON WHO WILL LEAD THE PROJECT: F.L. Oliveria

JUSTIFICATION: All existing technologies for direct control of SPB populations are either still in the experimental stage or have problems that prohibit their use in some situations. We have developed a biological control program that integrates available knowledge on SPB parasitoids and infestation dynamics with a newly developed natural product, Eliminade-TM, that can be applied in SPB infestations to begin immediately reducing SPB population levels. This technology is well-suited for application on commercial forests or private lands, wilderness areas, or National Forests. It is consistent with the principles of ecosystem management, and should significantly reduce short and long term losses from SPB. Eliminade-TM is environmentally safe, does not require EPA registration and could be made immediately available to land managers.

URGENCY: An operationally effective and environmentally acceptable direct control treatment for southern pine beetle is of highest priority for southern forestry. This treatment of SPB infestations will be particularly useful in sensitive areas (wilderness, research natural areas, etc.).

LINK TO NATIONAL FHP TECHNOLOGY DEVELOPMENT PRIORITIES: The biological control and management of SPB with the use of native parasitoids is high priority. Southern pine beetle is the single most destructive bark beetle of southern pines in the United States.

SCOPE OF APPLICATION: The results of this project are likely to be used throughout the entire range of SPB. This technology is well suited for use by commercial, private and public timber managers. Forest Health protection's first priority will be in the 13 states in Region 8. This should be accomplished by 2005.

RESEARCH BASIS: We believe SPB parasitoids are not able to control SPB infestations because adult parasitoids do not live long enough or produce enough eggs to effectively regulate SPB populations. We have made considerable research progress in gathering evidence in support of this idea. We have developed a synthetic food for adult SPB parasitoids, Eliminade-TM, which has been evaluated in laboratory experiments and has received preliminary tests under field conditions. We have demonstrated that Eliminade-TM is readily fed upon by all species of SPB parasitoid adults in the laboratory. Adults that are fed live longer than unfed individuals. Unfed adults quickly begin to resorb their mature eggs that are ready for oviposition, do not mature additional eggs, and the total complement of eggs within females rapidly decreases. We have a field formulation of Eliminade-TM that is incorporated into paint balls and can be rapidly applied to standing trees using paint ball guns. In field applications we have demonstrated that adult SPB parasitoids will feed on Eliminade-TM as it is encountered. In 1997, approximately 50% of adult female parasitoids that were collected from infestations where food had been applied to the trees the previous week had food present in their guts. We have also been able to increase parasitoid numbers in field test situations. During the 1997 summer field season three SPB infestations on the Holly Springs National Forest in Mississippi were treated with Eliminade-TM. Two of these infestations were controlled within six weeks and the third showed reduced infestation growth. Of four control infestations, three continued to grow during the experiment and the fourth died out when host type was eliminated. These experiments substantiate our belief that we have a potentially effective biological control treatment for SPB that is now ready for limited operational field testing and evaluation.

METHODS: The hypothesis to be tested is that spots receiving the parasitoid food, Eliminade-TM, and spots receiving a no nutritional treatment (controls) do not differ in rate of SPB infestation growth. Testing of this hypothesis will be on SPB infested spots in Texas, Arkansas or Louisiana which will be located with assistance of District personnel and FHP. The field crew will consist of one UA research specialist and one or two individuals from FHP. To enable the greatest possibility of a successful treatment

evaluation, we will minimize the effects of highly varying site, stand and beetle infestations, by including as many spots as is economically feasible in the study. The intent will be to have at least 15 treatment and 15 control spots, with more being used if possible. Applications of foodballs will be made on the initial visit to the spot (week 1). Paintball guns will be used to rapidly apply approximately 30 treatment balls to the bark of each infested tree in each infestation. Followup treatments will be made at week 2 and again at week 4. Spot monitoring is an essential component to the treatment evaluation process and extensive ground survey data will be taken at the time of initial visit, and again at week 2, week 4 and when the treatment period is complete at week 8. Statistical evaluation of the success of the treatment in relation to the hypothesis stated above, will be conducted by comparing rates of infestation growth between the two treatment types, and also by using SPBMODEL to predict growth of each infestation at the time of initial visit in relation to actual growth measured by on-the-ground spot monitoring.

MEASURE OF SUCCESS: Success will be demonstrated if we can reject the hypothesis that the growth rate of infestations does not differ in the two treatment regimes, and that spots receiving Eliminade-TM show a slower rate of growth than do untreated spots.

COOPERATORS: Principal Investigators are F.M. Stephen, University of Arkansas, Fayetteville; Co-investigator is L.E. Browne, Entopath Inc., Easton, PA

PRODUCTS: This project will produce a direct control treatment for SPB infestations that is environmentally acceptable and consistent with the principles of ecosystem management.

PUBLICATIONS: The project results will be reported in yearly progress reports and the final report will be a publication in a professional journal.

TECHNOLOGY TRANSFER: This SPB infestation treatment technique will be transferred to Forest Service District personnel by FHP. Forest Health Protection will train District personnel using video presentations and "hands-on" in the woods training. This training will be extensive in R-8 in FY2001 after the results of this project have been carefully reviewed and analyzed. An implementation plan will be developed by FHP Pineville Field Office in FY2000.

PROJECT DURATION: This project will last for two years (FY1999 and FY2000)

LONG TERM BUDGET:

FY1999 - $95,000 total FHP-WO funds

FHP STDP	Other Sources FHP-R8	Other Sources Univ. AR	Other Sources Entopath
$95,000	$8,000	$9,000	$15,000

FY2000 - $65,000 total FHP-WO funds

FHP STDP	Other Sources FHP-R8	Other Sources Univ. AR	Other Sources Entopath

$65,000 $8,000 $9,000 $15,000

FY1999 BUDGET REQUEST:

Item	Requested FHP	Other Sources	Organization
STDP	Funding	Amount	Name
Admin items:			
Salary	$38,000	$ 8,000	FHP - R8
Salary	$15,000	Entopath Inc.	
Salary	$ 9,000	Univ. AR	
Overhead			
Travel	$17,000		
Procurements:			
Contracting	$35,000		Entopath - Foodballs
Equipment	$ 2,000	$	
Supplies	$ 2,000	$	
Other	$ 1,000	$	

Total FY1999 request $95,000

BENEFIT AND COST: 131.24 see attached Production Function

LITERATURE, CITATIONS, ATTACHMENTS, etc.:

Beirne, B. P. 1962. Trends in applied biological control of insects. Ann. Rev. Entomol. 7: 387-400.

Beltz, R. C., D. F. Bertelson, J. L. Faulkner & D. M. May. 1992. Forest resources of Arkansas. USDA For. Ser. Res. Bull. SO-169. 48 pp.

Berisford, C W. 1980. Natural enemies and associated organisms, pp. 31-52. In R. C. Thatcher, J. L. Searcy, J. E. Coster & G. D. Hertel [eds.], The southern pine beetle. USDA For. Serv. Sci. Educ. Admin. Tech. Bull. 163l.

Bushing, R. W. 1967. Parasites of the western pine beetle, Dendroctonus brevicomis Le Conte (Coleoptera: Scolytidae) with particular reference to Roptrocerus xylophagorum (Ratzeburg) (Hymenoptera: Torymidae). Ph. D., University of California, Berkeley, CA.

Cooper, M. E. & F. M. Stephen. 1978. Parent adult reemergence in southern pine beetle populations. Environ. Entomol. 7: 574-577.

Coppel, H. C. 1986. Environmental management for furthering entomophagous arthropods, pp. 57-73. In J. M. Franz [eds.], Biological plant and health protection:

Biological control of plant pests and of vectors of human and animal diseases. G. Fischer Verlag. Stuttgart.

Coulson, R. N. 1979. Population dynamics of bark beetles. Ann. Rev. Entomol. 24: 417-447.

Coulson, R. N., W. S. Fargo, P. E. Pulley, J. L. Foltz, D. N. Pope, J. V. Richerson & T. L. Payne. 1978. Evaluation of the re-emergence process of parent adult Dendroctonus frontalis (Coleoptera: Scolytidae). Can. Entomol. 110: 475-486.

Doutt, R. L. 1964. Biological characteristics of entomophagous adults, pp. 145-167. In P. DeBach [eds.], Biological control of insect pests and weeds. Chapman Hall. London.

Flanders, S. E. 1942. Oosorption and ovulation in relation to oviposition in the parasitic Hymenoptera. Ann. Entomol. Soc. Am. 35: 251-266.

Flanders, S. E. 1945. Uniparentalism in the Hymenoptera and its relation to polyploidy. Science 100: 168-169.

Flanders, S. E. 1947. Elements of host discovery exemplified by parasitic Hymenoptera. Ecology 28: 299-309.

Flanders, S. E. 1950. Regulation of ovulation and egg disposal in the parasitic Hymenoptera. Can. Entomol. 82: 134-140.

Foster, M. A. & W. G. Ruesink. 1984. Influence of flowering weeds associated with reduced tillage in corn on a black cutworm (Lepidoptera: Noctuidae) parasitoid, Meteorus rubens (Nees von Esenbeck). Environ. Entomol. 13: 664-668.

Gano, L. 1917. A study in physiographic ecology in northern Florida. Bot. Gaz. 63: 337-372.

Gauld, I. D. & B. Bolton. 1988. The Hymenoptera. Oxford Univ. Press. Oxford. 332 pp.

Hagen, K. S. 1976. Role of nutrition in insect management. Proc. Tall timbers conference on ecological animal control by habitat management. Tallahassee, FL. 6:221-261.

Hagen, K. S. 1986. Ecosystem analysis: Plant cultivars (HPR), entomphagous species and food supplements, pp. 151-197. In D. J. Boethel & R. D. Eikenbary [eds.], Interactions of plant resistance and parasites and predators of insects. Halsted Press. New York.

Hedden, R. L. 1978. The need for intensive forest management to reduce southern pine beetle activity in east Texas. So. J. Appl. For. 2: 19-22.

Hopkins, A. D. 1893. Catalogue of West Virginia Scolytidae and their enemies: with a list of trees and shrubs attacked. West Virginia Agric. Expt. Sta., Bull. 31: 121-168.

Hopkins, A. D. 1899. Report on investigations to determine the cause of unhealthy conditions of the spruce and pine from 1880-1893. West Virginia Ag. Exp. Sta. Bull. 56. 461 pp.

Hopkins, A. D. 1909. Practical information on the scolytid beetles of North American forest. Bark beetles of the genus Dendroctonus. U. S. Dept. Agric., Bur. Entomol., Bull. 83, part I.

House, H. L. 1976. Nutrition of natural enemies, pp. 151-182. In R. L. Ridgeway & S. B. Vinson [eds.], Biological control by augmentation of natural enemies. Plenum Press. New York.

Jervis, M. A. & N. A. C. Kidd. 1986. Host-feeding strategies in hymenopteran parasitoids. Biol. Rev. 61: 395-434.

Jones, J. M. & F. M. Stephen. 1994. Effect of temperature on development of hymenopterous parasitoids of Dendroctonus frontalis (Coleoptera: Scolytidae). Environ. Entomol. 23: 457-463.

Kidd, N. A. C. & M. A. Jervis. 1989. The effects of host-feeding behaviour on the dynamics of parasitoid-host interactions, and the implications for biological control. Res. Popul. Ecol. 31: 235-274.

Leius, K. 1961a. Influence of food on fecundity and longevity of adults of Itoplectis conquisitor (Say) (Hymenoptera: Ichneumonidae). Can. Entomol 93: 771-780.

Leius, K. 1961b. Influence of various foods on fecundity and longevity of adults of Scambus buolianae (Htg.) (Hymenoptera: Ichneumonidae). Can. Entomol 93: 1079-1084.

Leius, K. 1963. Effects of pollens on fecundity and longevity of adult Scambus buolianae (Htg.) (Hymenoptera: Ichneumonidae). Can. Entomol 95: 202-207.

Leius, K. 1967. Influence of wild flowers on parasitism of tent caterpillar and codling moth. Can. Entomol 99: 444-446.

Linit, M. J. & F. M. Stephen. 1983. Parasite and predator component of within-tree southern pine mortality. Can. Entomol. 115: 679-688.

Linit, M. J. & F. M. Stephen. 1978. Comparison of methods for estimation of attacking adult populations of Dendroctonus frontalis. J. Econ. Entomol. 71: 732-735.

Mendel, Z. 1988. Effects of food, temperature, and breeding conditions on the life span of adults of three cohabitating bark beetle (Scolytidae) parasites (Hymenoptera). Environ. Entomol. 17(2): 294-298.

Moore, G. E. 1972. Southern pine beetle mortality in North Carolina caused by parasites and predators. Environ. Entomol. 1: 58-65.

Moser, J. C., R. C. Thatcher & L. S. Pickard. 1971. Relative abundance of southern pine beetle associates in East Texas. Ann. Entomol. Soc. Am. 64: 72-77.

Powell, W. 1986. Enhancing parasitoid activity in crops, pp. 319-340. In J. Waage & D. Greathead [eds.], Insects parasites. Academic Press. London.

Price, T. S., C. Doggett, J. M. Pye & T. P. Holmes. 1992. A history of southern pine beetle outbreaks in the southeastern United States. So. For. Ins. Work. Group. Georgia For. Comm. Macon, GA. 62.

Sampson, P. R. 1984. The biology of Roptrocerus xylophagorum (Hymenoptera: Torymidae) with a note on its taxonomic status. Entomophaga 29: 287-298.

Stephen, F. M. 1994. Potential for suppressing southern pine beetle populations by enhancing effectiveness of their hymenopteran parasitoids. Proc. IUFRO Conf. on Population Dynamics of Forest Insects. In Press.

Stephen, F. M. & M. P. Lih 1985. A Dendroctonus frontalis infestation growth model: organization, refinement, and utilization, pp. 186-194. In S. J. Branham and R. C. Thatcher (eds.), Integrated Pest Management Research symposium: The Proceedings. U.S. Dept. Agric. For. Serv., So. For. Expt. Sta., Gen. Tech. Rept. SO-56. New Orleans, La.

Stephen, F. M., M. P. Lih & G. W. Wallis. 1989. Impact of arthropod natural enemies on Dendroctonus frontalis (Coleoptera: Scolytidae) mortality and their potential role in infestation growth, pp. 169-185. In D. L. Kulhavy & M. C. Miller [eds.], Biological Control of Dendroctonus and Ips Bark Beetles. Stephen F. Austin State University Press. Nacogdoches, Tex.

Stephen, F. M. & H. A. Taha. 1976. Optimization of sampling effort for within-tree populations of southern pine beetle and its natural enemies. Environ. Entomol. 5: 1001-1007.

Stephen, F. M. & H. A. Taha. 1979a. Area-wide estimation of southern pine beetle populations. Environ. Entomol. 8: 850-855.

Stephen, F. M. & H. A. Taha. 1979b. Tree mortality and beetle population measurements as components of treatment evaluation procedures on discrete forest

management units, pp. 45-53. In J. E. Coster & J. L. Searcy [eds.], Evaluating Control Tactics for the Southern Pine Beetle. Symp. Proc. USDA For. Serv. Tech Bull. 1613.

Syme, P. D. 1975. The effects of flowers on the longevity and fecundity of two native parasites of the European pine shoot moth in Ontario. Environ. Entomol. 4: 337-346.

Thatcher, R. C., J. L. Searcy, J. E. Coster & G. D. Hertel. 1980. The southern pine beetle. USDA For. Serv. Sci. Educ. Admin. Tech. Bull. 163l. 266 pp.

Turchin, P., P. L. J. Lorio, A. D. Taylor & R. F. Billings. 1991. Why do populations of southern pine beetles (Coleoptera: Scolytidae) fluctuate? Environ. Entomol. 29(2): 401-409.

Wagner, T. L., J. A. Gagne, P. J. H. Sharpe & R. N. Coulson. 1984. A biophysical model of southern pine beetle, Dendroctonus frontalis Zimmermann (Coleoptera: Scolytidae), development. Ecol. Modeling 21:
125-147.

STDP PRODUCTION FUNCTION

PROJECT NUMBER: R8 - 1999 - 02

PROJECT COST:

Year	0	1	Total
STDP request	$ 95,000	$65,000	$160,000
Other	$ 32,000	$ 32,000	$ 64,000
Total	$127,000	$97,000	$224,000

PROJECT OBJECTIVES: To measure infestation growth in spots treated with Eliminade-TM in order to demonstrate on an operational basis that southern pine beetle infestation growth can be slowed or stopped by native parasitoids if they have a nutritional supplement available when they emerge. The overall project goal is to develop effective and marketable parasitoid food application protocols that complement existing SPB control strategies and can be easily transferred to District personnel.

ASSUMPTIONS:
* Average infestation size is 50 trees
* Average number of days from detection to conventional treatment is 30 days
* Average age of supplement treated infestations is 55 years on the National Forests
* Average volume of a killed tree is 64 cubic feet at age 55 years
* Average infestation will increase by 50 trees in 30 days

* Nutritional supplement treatment will reduce the number of trees killed in an infestation by 20%
* Sixty percent (30 trees) of the trees in an infestation will be treated

BACKGROUND DATA:
* Conventional cut and remove treatments of SPB infestations are 85% effective with one entry
* Average age of the National Forests is 55 years
* Southern yellow pine green stumpage is $1.70 per cubic foot
* An average of 2420 SPB infestations are treated using cut and remove each year (FY91-FY97) on National Forests in R8
* Nutritional supplement costs $200 per 1000 foodballs
* Thirty nutritional supplement foodballs will be used on each tree treated
* Nine hundred nutritional supplement foodballs will be used to treat an average infestation
* Each nutritional supplement treatment will take about one hour of a persons time ($15.00)
* Discount rate is 4%

EXPENDITURE & OUTPUT VALUES (EOV) WITHOUT PROJECT:
EOV Without Project = (2420 infestations) * (85% effectiveness for conventional cut and remove) * (50 tree growth / infestation) * (64 cubic feet / tree) * ($1.70 / cubic foot) * (2 years) = $22,380,160 = discounted to $21,949,790

EXPENDITURE & OUTPUT VALUES (EOV) WITH PROJECT:
EOV With Project = (2420 infestations) * (85% effectiveness for conventional cut and remove) * (50 tree growth / infestation) * (20% reduced tree mortality) * (64 cubic feet / tree) * ($1.70 / cubic foot) = $2,238,016

(2,057 infestations) * ($15.00 person time / infestation) = $30,855 for treatment labor

(30 trees / infestation treated) * (2,057 infestations) * (30 foodball / treated tree) * ($.20 / foodball) = $370,200 for treatment foodballs

($2,238,016) - ($30,855) - ($370,200) = ($1,836,961) * (2 years) = $3,673,922 = discounted to $3,603,272

BENEFIT (CHANGES IN EOV) ATTRIBUTABLE TO PROJECT:
($21,949,790 without project) - ($3,603,272 with project) = $18,346,518 benefit attributable to project

BENEFIT / COST RATIO:
Benefit / Cost Ratio = ($18,346,518) / ($220,269 discounted STDP) = 83.29

BENEFIT ATTRIBUTABLE TO STDP:
Benefit Attributable to STDP Funds = (83.29) * ($224,000 STDP costs) = $18,657,278

PNV OF PROJECT:
PNV of Project = ($18,346,518) - ($220,269 discounted STDP costs) = $18,437,009

PNV OF STDP:
PNV of STDP = ($18,657,278) - ($224,000 STDP request) = $18,433,278