# Special Technology Development Program
# New Project Proposal

**PROJECT NUMBER:** R8-2001-04

**PROJECT TITLE:** Evaluation of Cool Season Aerial Applications of Eliminade-TM to Enhance Native Parasitoids for Biological Control of Southern Pine Beetle

**PROJECT STATUS:** New-not previously funded

**EXPECTED PROJECT DURATION:** One year

**EXPECTED COMPLETION DATE OF THE PROJECT:** FY02

**SUBJECT: (mark all that apply using 1 for primary category and 2 for secondary categories)**:
Biological Control_1__ Invasive Species___ Methyl Bromide Alternatives___ Models___
Monitoring_2__ Organism Biology_2__ Pesticides: Microbial ___ Pesticides: Synthetic___
PTIPS___ Population__2_ Risk and Hazard___ Remote Sensing_3__ Semiochemicals___
Silvicultural Technology___ Social Values___ Spray Technology___
Other_____

**STATUS OF SUBJECT SPECIES:** Native

**PROJECT OBJECTIVES:** Our goal is to positively influence parasitoid efficacy and numbers by providing southern pine beetle (SPB) infestations with Eliminade-TM and to measure these effects by counting infestations within and outside of treated areas in the early summer of 2002 (after the spring spot proliferation period). The long-term objective of this project is to develop, statewide or perhaps south-wide, annual cool season management strategies for SPB in order to prevent such catastrophic epidemics as experienced in Alabama during 1999 and 2000.

**BRIEF DESCRIPTION OF PROJECT:** We will apply parasitoid food to all active SPB infestations throughout one or two large forested areas during the fall, early winter, and early spring months; while the weather is still warm enough for beetles and parasitoids to colonize new trees. Spots in treated and untreated areas will be surveyed for SPB activity and GPS location of this activity throughout the cool period. Subsets of infested trees will be surveyed for parasitoid abundance and feeding efficacy as measured in emergence trap collections. Most tree mortality caused by southern pine beetle occurs following the spring migration flight in spring and early summer. This also is the time that infestations proliferate. During the winter, SPB infestations are at their lowest numbers but within-tree densities of beetles may remain high. Thus, we will demonstrate the efficacy of cool period enhancement of parasitoids as measured by subsequent spring spot proliferation detected by mid-July on the treatment and control sites. .

**FHP LEAD CONTACT:**


| Name | Affiliation (Office or Dept.) | Phone, E-mail, Fax |
|---|---|---|
| Forrest L. Oliveria | Forest Health Protection | Office 318-473-7294<br>foliveria@fs.fed.us<br>`FAX 318-473-7117 |


**PRINCIPAL INVESTIGATOR (S):**


| Name | Affiliation (Office or Dept.) | Phone, E-mail, Fax |
|---|---|---|
| Lloyd Browne | Entopath Incorporated | Office 610-250-0946<br>lbrowne@entopath.com<br>FAX 610-250-7078 |
| Fred Stephen | University of Arkansas | Office 501-575-3404<br>fstephen@uark.edu |

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**COOPERATORS:**

| Name | Affiliation (Office or Dept.) | Phone, E-mail, Fax |
|---|---|---|
| Oakmulgee RD | National Forests in Alabama | Office 205-926-9765 |
| Forest Health Protection | R8 | Office 318-473-7286 |

**COOPERATOR INVOLVEMENT:**

| Name | Role | Time Commitment |
|---|---|---|
| Oakmulgee RD | Staff for SPB detection & survey | 30 days |
| Forest Health Protection | Detection/Survey/Technical Assistance | 60 days |

**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™, that when applied in SPB infestations 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™ is environmentally safe, does not require EPA registration and could be made immediately available to land managers.

This project represents a novel biological control tactic for management of southern pine beetle. This project will add to the validity of the tactic by providing additional spot treatment data. But most importantly it permits evaluation of this novel treatment tactic during the winter months. Little has been published on population dynamics of southern pine beetle during the cool winter months and their relationship to subsequent spring population proliferation. Data from these studies will impact other direct methods of SPB control. Our data show that following the spring spot proliferation numbers of infested spots decrease as beetles leave some spots and join others. Some of the "fell and leave" spot treatments are performed on spots where the beetles have previously emerged. This project offers an opportunity to accomplish economic control of SPB on a regional basis. It will also improve SPB risk rating systems as it incorporates spatial aspects of the forest type (using either Forest Health's sketch map, a module of Geolink, or the Oakmulgee District's Arc View software) and insect populations.

**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 over large areas during the cool season to reduce the SPB populations and thereby reduce the spring migration. This project will be implemented on the National Forests in Alabama and private lands in Alabama where the losses due to southern pine beetle populations for the past two years have been the worst in recorded history.

**NATIONAL FHP TECHNOLOGY DEVELOPMENT PRIORITY** (check one):

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

**TECHNICAL COMMITTEE DEVELOPMENT PRIORITY** (check one):

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

Priority 5: __ Priority 6: __ Priority 7: __ Priority 8: __

**SCOPE OF APPLICATION:** These project results will be applicable throughout the entire range of the southern pine beetle.

**RESEARCH BASIS:** We believe SPB parasitoids are not always able to control SPB infestations because adult parasitoids do not live long enough or produce sufficient 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™, which has been evaluated in laboratory experiments and has received preliminary tests under field conditions. We have demonstrated that Eliminade™ is readily fed upon by all species of SPB parasitoid adults in the laboratory. Adults that are fed (particularly under harsh environmental conditions) live longer than individuals that are not fed. Starved 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 two formulations of Eliminade-TM. One is incorporated into paint balls and can be rapidly applied to standing trees using paint ball guns. The second formulation is a spray for aerial applications. Both formulations incorporate some degree of rain fastness. In field applications using food coloring as an indicator dye we found that adult SPB parasitoids feed on Eliminade-TM encountered on tree boles. In 1999 ground-based treatments of Eliminade in food balls, applied to tree boles, resulted in approximately 75% of parasitoid adults feeding on the food. Subsequent spraying of an infestation from a helicopter also yielded 75% of the parasitoids collected daily over the next 3 days had fed. This experiment demonstrated that parasites also forage in the pine canopies as well as they do on infested tree boles. Spray cards indicated that almost no food spray penetrated beneath the canopy. Based on that research we began, during the 2000 season, spraying southern pine beetle spots using fixed-wing aircraft. The University of Arkansas has conducted a major study of parasitoid feeding in plots treated with food balls, sprayed from aircraft and food sprayed on understory plants. They found that canopy applications of food were an effective method for feeding parasitoids. Results from the 1999 research are in press (Stephen and Browne, 2000). During the 1997 summer field season beetle-infested trees in three SPB infestations on the Holly Springs National Forest in Mississippi were treated with the Eliminade-TM food-ball formulation. Two of these infestations were controlled within six weeks and the third showed reduced infestation growth. Of four monitored but untreated infestations, three continued to grow during the experiment and the fourth died out when host type was eliminated. During 1999 and 2000, 48 infestations were studied on the Bankhead National Forest, the Oakmulgee District of the Talladega National Forest, National Forests in Alabama and on Gulf States Paper Co. Inc. Lands. Twenty-five of these infestations were untreated spots that were monitored in the same way and at the same time as the treated spots. Ten spots were treated with food balls and 13 were sprayed from the air. There is a delay time of about 3 weeks before the positive effects of food on parasitoid survival and fecundity, and the subsequent impact of parasitoids on SPB populations are reflected in numbers of new tree attacks. Our analysis of compared numbers of newly attacked trees during the 3 weeks following the first application of food (a basis for the beetle activity in the spot) with numbers of new attacked trees in the three weeks following this period (weeks 4-6). In the 23 treated spots 17 spots were still active at the end of the first 3 weeks. In these spots there were 208 fewer trees attacked in weeks 4-6 than in weeks 1-3 for an average decrease of 12.23 new attacked trees per spot. Meanwhile in the 25 untreated spots 18 were still active at the end of the first 3 weeks. In these 18 spots there were an additional 27 new attacked trees in weeks 4-6 as compared to weeks 1-3 for an average increase of 1.5 attacked trees. In each of the treatment compartments and each year there were fewer trees killed in the treatments than in the controls. However, there was very high variation in the untreated spots that has prevented us from assigning probability estimates that are significant to differences between treated and untreated spots. However, the variance among the treated and untreated was highly significant. The variance was low within the treated spots and statistically different from the untreated variance with a probability of 0.0008. The most dramatic feature of the summer data is that nearly all spots are declining in numbers of tree kills, both treated and untreated. It is clear that beetles leave most spots and congregate in a few spots that enlarge, sometimes dramatically. We are convinced that augmentation of parasitoids has an effect on SPB populations and reduces tree losses. We are equally convinced that the summer season is the wrong time to fight the southern pine beetle.

**METHODS:** A large block of the Oakmulgee District of the Talladega National Forest, National Forests in Alabama and possibly adjacent private lands will be selected in the fall (late September) and all of the active infestations will be GPS mapped. The area will then be divided into two sections each containing approximately equal numbers of infestations. The spots will be visited at 3-week intervals in both areas and the number of infested trees counted and marked. GPS positions will be recorded at

4 or more positions enclosing the infested trees. Using Sketch Map or Arc View, these spots will be redrawn so as to apply food evenly over the infestation (often the area containing currently infested trees will be less than one acre, a size that is hard to accurately spray with fixed- wing aircraft). Parasitoid food will be applied at about 3-week intervals depending on climatic conditions. Data recorded will include number of newly infested trees in all spots and beetle/parasitoid ratios (as determined by emergence traps on specific trees in treatment and control infestations) in a randomly selected subset of trees. Collection and dissection of adult parasitoids to establish feeding effectiveness will also be conducted. Late fall and early spring spot-detection flights of the area will be made to locate possible new spots from a possible fall migration.

GPS mapping will be adapted to visually display the realistic outcome of area-wide treatments. Sketch-map or Arc View converted GPS polygons that will be used to efficiently direct aircraft applications onto areas containing only infested trees represent guidelines that will relate directly to Forest Health Protection activities in SPB suppression.

**MEASURES OF SUCCESS:**

**Standard of Success:** The standard of success will be measured by the number of SPB spots detected in both treated and untreated areas during spring and early summer of 2002. The cool season food applications should reduce beetle populations taking part in the 2002 spring migration. The study areas should be in excess of 10 square miles of forest in order to overcome effects of migration into the treated area. Of course no one knows how far these beetles fly, perhaps hundreds of miles. However, we conducted a similar test in the summer months of 2000 on Gulf States Paper Company, Inc. land. Here each of two areas was approximately six square miles in size and we noted no drastic changes in spot growth through time. In this test all of the treated spots showed a reduction in rate of tree killing while killing rates in some of the untreated spots increased.

**Expected Outcomes**: We believe the cool season offers an exceptional opportunity to concentrate any direct spot control measure because of the reduced numbers of infestations to be treated in an area and lack of wasted control efforts on abandoned spots that occurs in the summer months. If cool season food applications reduce the number of new infestations in the following year by 90% then an annual beetle suppression activity could be established regardless of the number of beetles present in order to prevent future epidemics. An ongoing program is the only one that makes economic sense. No private company can afford to maintain product inventory and experienced personnel in those areas and times when beetles are endemic. Also, no land manager can afford two to four southern pine beetle epidemics per crop rotation.

**Implementation of Products/methods:** Following a successful demonstration of the cool season southern pine beetle suppression strategy Eliminade™ will be marketed through a service to large land managers on a fee per acre basis. The service will include spot detection, ground evaluation and treatment.

**PRODUCTS AND DUE DATES**: The products, product manufacturing capabilities and application technologies exist. Several large Alabama land managers have cooperated with previous summer application studies and are prepared to purchase product and/or services as soon as the most efficacious control strategy can be devised. Food applications previously made to summer spots substantially reduced timber losses but the summer season does not offer the best window of opportunity. During the summer, effort is wasted treating spots that are inactive or in the process of becoming inactive. In addition, those spots that remain active through the summer attract beetles from collapsing spots. These immigrant beetles cause some infested areas to grow rapidly and, in part, negate the effects of the parasitoids on the indigenous population.

**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 FY2002 after the results of this project have been carefully reviewed and analyzed. FHP Pineville Field Office in FY2002 will develop an implementation plan. The National Forests may wish to contract for part or all of the Entopath Inc. services pending acceptance of the procedure as a valid control measure.

## LONG-TERM BUDGET REQUEST:

FY2001 - $65,000 total FHP-WO funds

| FHP STDP | Other Sources FHP-R8 | Other Sources Univ. AR | Other Sources Entopath | Other Sources Oakmulgee RD |
|---|---|---|---|---|
| $65,000 | $15,000 | $10,000 | $10,000 | $5,000 |

FY2001 BUDGET REQUEST:

| | Item | Requested FHP STDP Funding | Other Sources Amount | Organization Name |
|---|---|---|---|---|
| Admin items: | | | | |
| | Salary | | $10,000 | Entopath Inc. |
| | Salary | $20,000 | $10,000 | Univ. AR |
| | Salary | | $ 5,000 | Oakmulgee RD |
| | Overhead | | | |
| | Travel | $10,000 | $ 8,000 | FHP – R8 |
| Procurements: | | | | |
| | Contracting | $30,000 | | Entopath -food |
| | Equipment | $ 2,000 | $ | |
| | Supplies | $ 2,000 | $ | |
| | Other | $ 1,000 | $ | |
| Total FY2001 request | | $65,000 | | |

**BENEFIT AND COST:** 28.54 see attached Production Function

**LITERATURE, CITATIONS, ATTACHMENTS, etc.**

**Literature:**


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

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.

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. 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.

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.

Hanano TL. 1996. Effect of nutrition on egg production in southern pine beetle parasitoids. M. S. Thesis. University of Arkansas, Fayetteville, Arkansas.

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.

Mathews PL, Stephen FM. 1997. Effect of artificial diet on longevity of adult parasitoids of *Dendroctonus frontalis* (Coleoptera: Scolytidae). Environmental Entomology 26: 961-965

Mathews PL, Stephen FM. 1999. Impacts of an artificial diet and varied environmental conditions on longevity of *Coeloides pissodis* (Hymenoptera: Braconidae), a parasitoid of *Dendroctonus frontalis* (Coleoptera: Scolytidae). Environmental Entomology 28: 729-734

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 & L. E. Browne, 2000. Application of Eliminade™ parasitoid food to boles and crowns of pines (Pinaceae) infested with *Dendroctonus frontalis* (Coleoptera: Scolytidae). Can. Entomol. (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.

**STDP PRODUCTION FUNCTION**

PROJECT NUMBER: R8 – 2001 - 05

PROJECT COST:

| Year | 01 | Total |
|---|---|---|
| STDP request | $ 65,000 | $ 65,000 |
| Other | $ 40,000 | $ 40,000 |
| **Total** | **$ 105,000** | **$ 105,000** |

PROJECT OBJECTIVE: To measure infestation growth in spots treated with Eliminade-TM 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%
* Ninety-five percent (45 trees) of the trees in an infestation will be treated

BACKGROUND DATA:
* Conventional cut and remove treatments of SPB infestations are 80% effective with one entry
* Average age of the National Forests in Alabama is 70 years
* Southern yellow pine green stumpage is $2.00 per cubic foot
* An average of 800 SPB infestations are treated using cut and remove each year (FY91-FY97) on National Forests in Alabama
* Eliminade-TM nutritional supplement costs is $85.00 per infestation per treatment
* Aerial application cost $500.00 per four infestations treated
* The application cost to treat 800 infestations is $100,000.00
* Each nutritional supplement treatment will take about one hour of a person's time ($15.00)
* Discount rate is 4%

**CALCULATIONS**

EXPENDITURE & OUTPUT VALUES (EOV) WITHOUT PROJECT:

EOV Without Project = (800 infestations) * (80% effectiveness for conventional cut and remove) * (50 tree growth / infestation) * (64 cubic feet / tree) * ($2.00 / cubic foot) * (1 years) = $4,096,000 = discounted to **$3,501,260**

EXPENDITURE & OUTPUT VALUES (EOV) WITH PROJECT:

EOV With Project = (800 infestations) * (80% effectiveness for conventional cut and remove) * (50 tree growth / infestation) * (20% reduced tree mortality) * (64 cubic feet / tree) * ($2.00 / cubic foot) = $819,200

(800 infestations) * ($15.00 person time / infestation) = $12,000 for treatment labor

($85.00 Eliminade/ infestation / treatment) * (800 infestations) * (2 treatments / infestation = $136,000 for Eliminade

($500.00 / aircraft flight) / (4 infestations treated per flight) = $125.00 per infestation per flight.

($125.00) * (800 / 4) = $25,000 for aircraft application

($819,200) + ($12,000) + ($136,000) + ($25,000) = $992,000 = discounted to **$847,961**

BENEFIT (CHANGE IN EOV) ATTRIBUTABLE TO PROJECT:
**$2,653,299** benefit attributable to project = ($3,501,260 without project) - ($847,961 with project)

BENEFIT/COST RATIO:
28.54 = ($2,653,299) / ($105,000 * .8548)

BENEFIT ATTRIBUTABLE TO STDP:
$2,996,700 = ($105,000) x (28.54)

PNV OF PROJECT:
$2,903,725 = ($2,996,700) – ($92,975 discounted STDP costs)

PNV OF STDP:
$2,548,299 = ($2,653,299) – ($105,000 STDP requested)