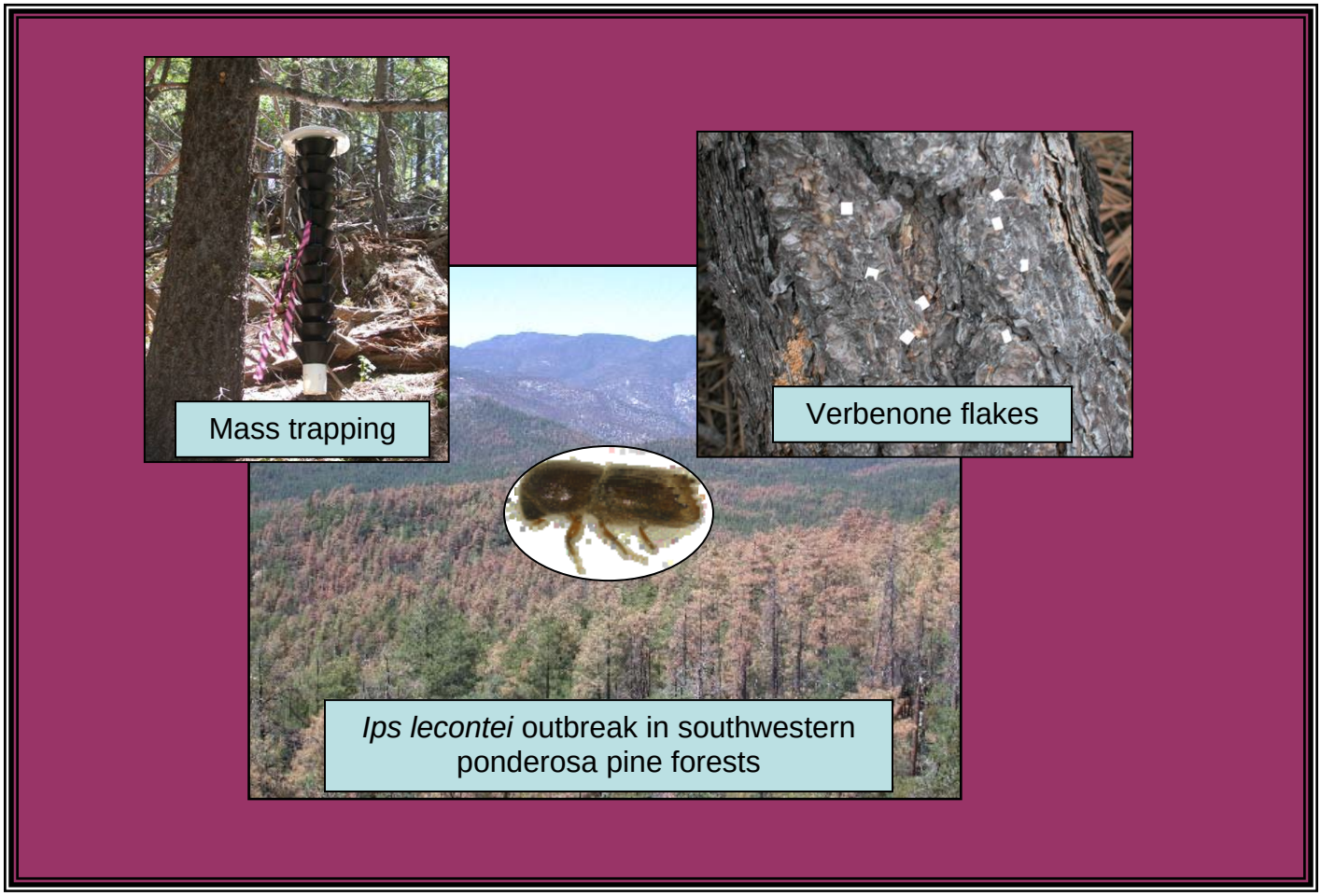
ASSESSMENT OF THE WESTERN BARK BEETLE INITIATIVE:

A COLLABORATIVE EFFORT BETWEEN FOREST SERVICE RESEARCH & DEVELOPMENT AND FOREST HEALTH PROTECTION

(FY 2004 – FY 2005)



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Executive Summary

Large scale outbreaks of bark beetles in recent years have severely impacted forest conditions in the western United States. In response to these outbreaks, the USDA Forest Service in cooperation with the Western Forestry Leadership Coalition drafted a report (2002) that called for increased short- and long-term treatments and development of research tools to mitigate bark beetle-caused impacts. Subsequently, the Forest Service Forest Health Protection (FHP) began the Western Bark Beetle Initiative in FY 2004. One component of the Initiative was a collaborative effort between FHP and Forest Service Research & Development (R&D); the goal being to accelerate development of management tools for control of bark beetles in the western U.S. During FY 2004 and FY 2005, $1,280,000 of FHP funds were allocated to address development of prioritized topics. FHP representatives from the Bark Beetle Technical Working Group reviewed submitted proposals and evaluated funded projects.

This report assesses collaborative efforts between FHP and R&D to accelerate development of new management tools for western bark beetles. This assessment is divided into the following sections:

1) Background information on the Initiative
2) Accomplishments to date relative to high priority needs
3) Critical technology and methodology gaps that remain
4) Evaluation of the interaction between FHP and R&D
5) Conclusions on success of the Initiative and recommendations for future funding direction

Advancements were made on several management tools used to control western bark beetles. Twenty-seven projects fully or partially funded by the Initiative have been completed or will be concluded by the end of FY 2006. Major accomplishments to date include:

- Development of semiochemical and trapping technology to improve monitoring, suppression, or prevention of bark beetles. The combined use of anti-aggregation pheromones and non-host volatiles shows increasing promise for area and individual tree protection against certain pine-infesting bark beetles.
- Evaluation of new insecticides for protecting individual trees or of existing insecticides for novel bark beetle species. For example, Onyx and Permethrin +C™ were shown to be equally effective as the industry standard, Sevin SL™, in protecting cypress and juniper trees against bark beetle (*Phloeosinus* species) attack. In addition, preliminary evidence suggests that two new systemic insecticides (emamectin benzoate and fipronil) may be effective in preventing attacks by a number of different bark beetle species.

If additional short-term funding becomes available for improving management tools for western bark beetles, priority should be given to determining the impacts

of hazardous fuel mitigation treatments on bark beetle populations, and continued evaluation on new single tree protection tools. If alternative funding mechanisms for multi-year studies are available, determining effectiveness of silvicultural strategies and developing best management options and IPM strategies for protection of critical ecosystems and habitats should be set as priorities. Although these latter topics are extremely important, they are not conducive to a one-year funding cycle.

Based on input solicited from funding recipients and FHP representatives, a dedicated pool of money that focused on applied technology development and rapid assessment of potential tools were viewed as positive aspects of the Initiative. The one-year funding cycle, which restricted the type of studies and was not flexible enough for the planning, designing, execution, and completion of certain projects, and timing of Request for Proposals (RFP) were viewed as negatives by some researchers.

In many cases there was excellent collaboration and coordination between FHP entomologists and R&D scientists in accelerated development of management tools for western bark beetles. However, in other instances, there seemed to be a lack of communication between R&D and FHP in development of proposals. The short turn around time between RFP and proposal deadline may have minimized the opportunity for communication and planning. Increased time for initial planning between R&D and FHP would help assure success of future programs.

Overall, the Western Bark Beetle Initiative has been an effective means of prioritizing identified technology gaps and allocating monies to address them. Similar future programs should emphasize more upfront planning in coordinating FHP and R&D efforts to focus on fewer selected priority topics. Furthermore, there should be improved synthesis of results emanating from projects addressing the same priority topic. This should result in even better efficiency of limited resources and greater acceleration of developing tools for management of western bark beetles.

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Purpose and Scope of Initiative

Tree mortality from bark beetles increased substantially in many parts of the West during 2003 and 2004 (***Figure 1***), particularly in forests stressed by widespread, prolonged drought and overstocked stands (USDA Forest Service, 2005), and elevated temperatures affecting survival and success of high elevation bark beetle species. Essentially all conifer forest types have been heavily impacted. Mortality caused by bark beetles attacking drought-stressed trees in piñon woodlands of the Southwest affected over 3 million acres during 2003. Mountain pine beetle, Douglas-fir beetle, and spruce beetle caused tree mortality on more than 3 million acres during 2004. The amount of western pine beetle-caused tree mortality reached unprecedented levels in southern California where approximately 152,000 acres were infested. In addition, fir and pine engravers, Jeffery pine beetle, and western balsam bark beetle caused substantial tree mortality on over 2.5 million acres during this same time period.

In response to large scale outbreaks, the Western Bark Beetle Initiative (WBBI) became an integrated management-research effort designed to accelerate efforts to improve the health of western coniferous forests. In FY 2004 and FY 2005, the USDA Forest Service (FS) Forest Health Protection (FHP) allocated $7 million annually to prevention, suppression, and restoration activities. These funds were allocated programmatically to the Regions to provide known amounts at the beginning of each fiscal year. These funds were separate from project funds that are allocated later in the year on a competitive basis. FHP also allocated $700,000 in FY 2004 and $580,000 in FY 2005 for the development of management tools through a collaborative approach between FHP and FS Research and Development (R&D) scientists. The Bark Beetle Technical Working Group (BBTWG) (bark beetle specialists comprised of state and federal agencies, universities, and private industry) identified technology gaps to be addressed by this Initiative, and FHP representatives reviewed submitted proposals and evaluated funded projects. This report summarizes results generated from the technology development portion of the WBBI program.

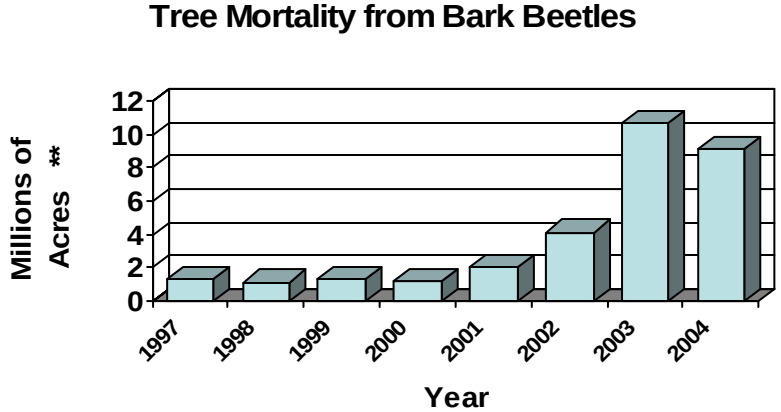

Figure 1. *Acres of aerially detected bark beetle-caused tree mortality in the western United States (USDA Forest Service, 2005).*

** Estimated acres with some level of mortality. Not all trees on all acres were dead.*

Background Information on Initiative

On November 18-20, 2003, the annual BBTWG meeting convened in Durango, CO. At the request of Rob Mangold (FHP Director-Washington Office (WO)) and Jim Reaves (former R&D Director of Vegetation Management and Protection Research-WO), the BBTWG initiated discussion on developing a list of technology gaps that, if addressed, could enable land managers to diminish impacts caused by bark beetles in the western United States. Based on discussion at this meeting and review by Mangold and Reaves, ten topics were identified and prioritized for accelerated study. Earlier recommendations for research activities were outlined in the 2002 Western Bark Beetle Report (see Appendix I) and they served as an additional guide for prioritizing the list of identified technology gaps.

On December 11, 2003, a letter was sent to Research Station Directors and Regional FHP Directors soliciting proposals addressing the WBBI list of priority topics. Directions for proposal submission stated they should be submitted by FS research scientist(s) with FHP entomologist(s) as sponsors. In addition, proposals should show a distinct interface with FHP management efforts.

A WBBI panel consisting of one FHP representative from each western Forest Service Region (Appendix II) rated submitted proposals in January 2004 using a list of criteria described in the Request for Proposals (RFP). Reviewers excused themselves if their name was on a proposal, in which case the average rating of other reviewers was used in evaluating proposals. Recommendations for funding were provided to Mangold and Reaves on January 28, 2004, with final selection of proposals determined by them in February 2004. A similar process of proposal requests, review, and funding selection was followed in FY 2005 using the same FY 2004 list of priority topics. See Appendices III and IV for a list of funded projects, investigators, funding level, and status of products.

Results and Accomplishments of the Initiative

All recipients of WBBI funding were required to present their results and accomplishments at the annual BBTWG meetings in 2004 (Homer, AK) and in 2005 (Midway, UT). In addition, funding recipients were required to submit brief summaries to the FHP Washington Office in January of 2005 and 2006. Summaries were to include the following:

- State which WBBI priorities were addressed
- Principal findings of the project
- How does the study relate to research and development emphasis areas in the western bark beetle report of 2002
- Describe potential management implications for the study

Based on these summaries, priority topics for technology and methodology development are discussed below in regard to what was accomplished, tools developed, and which technology gaps need additional work.

A. Determine best management options for bark beetles in critical ecosystems where sufficient information is lacking (e.g. southwestern ponderosa pine, limber, whitebark pine, and subalpine fir)

Projects included developing management options for bark beetles in whitebark pine and ponderosa pine ecosystems. Management strategies investigated included pheromone (mass trapping and verbenone) and silvicultural (thinning, thinning + prescribed burns) treatments.

Ongoing analysis is examining the effectiveness of individual and combined treatments; however, it is difficult to conduct a comprehensive study of what are "best management approaches" in one year. Evaluation of individual components or combinations of components is more feasible.

Studies on best management options for subalpine fir and limber pine ecosystems were not conducted.

B. Determine what bark beetle trap catches mean in terms of their flight periodicity and related population levels

Several projects examined the meaning of funnel trap catches in relation to bark beetle population levels and the timing of beetle flight. Bark beetle species investigated included spruce beetle, Douglas-fir beetle, mountain pine beetle, and ponderosa and piñon pine bark beetles (several species of *Dendroctonus* and *Ips*). Although variation exists in annual flight patterns, in general, timing of bark beetle flight is now well understood for most of these species. Flight patterns of other bark beetle species (e.g., western balsam bark beetle, cypress and cedar bark beetles) have not been as thoroughly studied.

Despite several studies attempting to unravel the meaning of trap catches in relation to population levels, more work is still needed to determine if there are any significant relationships other than being able to state that more beetles were caught during an outbreak phase. A workshop that discusses the meaning of results from different bark beetle/host systems, and how we can move forward to being able to develop predictive models, if possible, would be valuable. Future short-term focus should be centered on those bark beetle/host systems where preliminary evidence suggests there is a relationship between trap catch and beetle populations (Douglas-fir beetle, spruce beetle) and eliminate those where there does not appear to be any strong pattern (pine beetles). Separate longer term funding sources could be used to investigate basic pine bark beetle semiochemical ecology to really understand what semiochemicals (and how) we should be deploying to maximize beetle response.

C. Determine the conditions under which a trap-out strategy is effective. For example, how do trap type, timing, pheromones, stand conditions and population levels influence the effectiveness of trap-out strategies?

Trap out strategies were investigated for western pine beetle, Douglas-fir beetle, and mountain pine beetle in whitebark pine forests.

Based on previous studies that have attempted trap-out strategies for reducing bark beetle impacts, one critical factor seems to be initiating trapping efforts before populations rise to epidemic proportions and/or populations are limited to localized areas. Final results of WBBI projects remain to be seen, but a trap-out strategy may be possible for Douglas-fir beetle, especially when combined with other management strategies such as sanitation, Methyl cyclohex anone (MCH), and thinning treatments. Use of trap-out strategies in pine-dominated ecosystems seems more limited in part because of less than satisfactory aggregation lures for some *Dendroctonus* species.

Similar to the recommendation of holding a synthesis workshop for determining the meaning of trap catches, a session that focuses on the results of this topic would be very useful.

D. Determine what the impacts of fuel mitigation work (chipping, slashing, wood gatoring, hydro-axing, etc.) are on bark beetle populations

Only one project was indirectly related to this topic area. Influence of fuel reduction and restoration treatments on bark beetle activity at the watershed scale was investigated through a modeling effort. However, the original intent of this topic was to consider how different slash management treatments related to fuel reduction projects impact bark beetle populations. In this regard, there were no field-based studies that examined this topic.

E. Quantify the effectiveness of anti-aggregant pheromones (e.g., MCH, verbenone) for management of western bark beetles

Several projects studied efficacy of anti-aggregation pheromones in reducing bark beetle attack, including MCH for Douglas-fir beetle and verbenone for mountain pine beetle, western pine beetle, red turpentine beetle, and pine engravers. Efficacy of anti-aggregation pheromones may be increased for some bark beetles when used in combination with non-host volatiles. Combined use of verbenone and non-host volatiles is discussed in more detail under topic *F*.

Results from the MCH/Douglas-fir beetle project have not been submitted; therefore efficacy of MCH in this study cannot be evaluated at this time. It was reported, however, that deployment of the microencapsulated MCH beads was easier, required less time, and used fewer personnel than

deploying conventional MCH bubble capsules. Results from previous Douglas-fir beetle studies in other geographic locations have shown a high level of MCH efficacy. However, mixed results have been found when using MCH to protect spruce stands against spruce beetle attack.

In contrast to MCH, efficacy of verbenone has been more inconsistent in protecting pine trees from attack by mountain pine beetle and western pine beetle. Part of the inconsistency seems to be associated with which bark beetle/host tree is being examined. In general, more consistent results have been obtained when trying to protect lodgepole and whitebark pine stands from mountain pine beetle attack. This has been true for both high-dose verbenone pouches and verbenone flakes. The success of protecting ponderosa pine stands from attack by western pine beetle has been more variable. Inconsistency in results may also be attributable to beetle population level and stage of outbreak under which studies were conducted. Recent studies have suggested there may be a population threshold level above which verbenone is less effective. The use of anti-aggregation pheromone treatments is a short-term strategy and is typically only recommended for incipient populations. They should be used in combination with other management tools, such as long-term, preventative silvicultural actions.

A workshop that focuses on synthesizing the numerous studies that have been conducted using verbenone would be very useful. However, on the whole, it appears that verbenone will be most effective in protecting stands of lodgepole and/or whitebark pine from mountain pine beetle attack when population levels are low to moderate.

F. Determine optimal mixtures of bark beetle semiochemicals (including non-host volatiles) for survey and management of western bark beetles

Determining the optimal blends of bark beetle semiochemicals was explored for western pine beetle, southern pine beetle, mountain pine beetle, and pine engravers.

Trap catches of western and southern pine beetle were doubled in Arizona by replacing the host compound in the commercially available lure (myrcene) with α-pinene. If these results are reproducible, this could lead to increased capability for mass trapping, improved monitoring, and better tree baits for suppression strategies.

Based on results of WBBI and previous studies, success of verbenone in reducing bark beetle attacks seems to be enhanced by including non-host volatiles. However, these synergistic effects may be primarily limited to *Dendroctonus* beetles. Both mountain pine beetle and western pine beetle attacks (*Dendroctonus* species) were reduced using a combination of

verbenone and non-host volatiles. In contrast, although verbenone flakes resulted in a significant reduction in pine engraver (*Ips* species) attacks and brood production, these decreases were not improved by adding non-host volatiles.

Important advancements have been made in determining optimal semiochemical mixtures for management of western bark beetles. Future work could be accelerated by concurrently assessing effects of selected non-host volatiles on pine feeding bark beetles across different geographic areas and population phases.

G. Develop and/or validate new pheromone release devices (e.g. Med-e-Cell).

WBBI projects evaluated efficacy of two pheromone release devices in addition to the commercially available bubble capsule and pouch dispensers. Verbenone flakes were tested on western pine beetle, mountain pine beetle, red turpentine beetle, and pine engraver beetles, and microencapsulated MCH beads are being tested on Douglas-fir beetle.

Preliminary findings suggest verbenone flake technology is an effective release device. Mountain pine beetle and pine engraver attacks were generally reduced on individual trees or in treated areas when compared with controls. The verbenone flakes were less effective at preventing western pine beetle attacks. Side-by-side efficacy comparisons of flakes with commercially available bubble capsules or pouches have not been conducted. In addition, field-elution rates of verbenone from flakes have not been compared with rates emanating from pouches.

Results from the study assessing efficacy of microencapsulated (MEC) MCH beads on Douglas-fir beetle have not been completed. Furthermore, Gillette and others had originally proposed to evaluate efficacy of MEC verbenone for several bark beetles attacking pines; however, the manufacturer has closed its production facility. Thus, it does not seem that MEC beads will provide a viable option as a release device in the future.

An economic analysis of different release devices would be useful to determine cost effectiveness of different technologies. In addition, Med-e-Cell technology (a pump-like device, capable of delivering fluids such as solutions containing pheromones for periods up to 90 days) was not evaluated by any WBBI studies, but has been examined for some bark beetle/host systems using Special Technology Development Program (STDP) funding.

H. Determine the effectiveness of traditional silvicultural strategies (including thinning) for western bark beetles

Four projects were initiated or completed on the effectiveness of traditional silvicultural strategies. Thinning treatments designed for improving forest health conditions and for increasing stand resistance to bark beetle attacks were examined in ponderosa pine stands in the Southwest and Black Hills of South Dakota and Wyoming. Principal findings in the Southwest showed thinning with and without prescribed burning had long-term effects on ponderosa pine water stress, growth, phloem thickness, resin flow, and bark beetle abundance. Pheromone-baited trap catches of *Dendroctonus* species were higher in unmanaged than managed stands, whereas catches of *Ips* species did not differ among treatments.

In addition, a project measuring long-term effects of thinning and fertilization treatments on susceptibility of spruce to spruce beetle attack was completed in Alaska. Implications from the study include a combination of thinning and fertilization treatments could reduce the number of beetle attacks on white spruce during periods of pre-epidemic beetle populations.

More definitive work is needed in this area of study; however, it is unrealistic to expect that meaningful results will be completed from projects that are initiated with only one-year of funding. More practical projects are ones evaluating previously established silvicultural actions and report the effectiveness of treatments for a given time period.

I. Improve single tree protection tools (e.g., traditional pesticides, neem)

Direct evaluation of existing and emerging insecticides to protect individual trees occurred in both years of the Initiative. Bark beetle/host systems being tested include bark beetles attacking juniper and cypress, western pine beetle on ponderosa pine, mountain pine beetle on lodgepole pine, and spruce beetle on spruce. In addition, a project quantifying insecticide drift from ground applications will have major implications on the application of insecticidal sprays in sensitive areas (e.g., riparian corridors). Entomologists are currently challenged to prescribe “no spray buffers” around sensitive areas based purely on anecdotal evidence. The current project has generated data critical to developing science-based prescriptions that will provide details on necessary widths of no spray buffers.

Although the duration of efficacy still needs to be resolved, two new preventative sprays (Onyx and Permethrin +C™) were at least as effective, if not more so, than the commonly used Sevin SL™ in the protection of juniper and cypress trees from bark beetle (*Phloeosinus* species) attack. Efficacy of two systemic insecticides (emamectin benzoate and friponil) is still being evaluated; however, preliminary findings are encouraging. Investigators believe potential management implications will likely include treatment of trees in environmentally or socially sensitive areas not currently permissible with conventional spray equipment.

Projects that are investigating efficacy of anti-aggregation pheromones alone or in combination with non-host volatiles may also result in alternative single tree protection tools.

No WBBI projects evaluated neem extracts as a single tree protection tool for western bark beetles.

J. Develop IPM strategies for the protection of critical habitats

Two projects worked to develop integrated pest management (IPM) strategies for the protection of critical habitats. A combination of treatments (anti-aggregation pheromones, suppression trapping, and sanitation removal of infested trees) to reduce western pine beetle-caused mortality of old growth ponderosa pine are being assessed. Investigators are continuing the analysis of integrated approaches to protect these threatened habitats.

Also, effectiveness of combining suppression trapping and anti-aggregation pheromones (verbenone and verbenone plus non-host volatiles) to protect high value, high elevation whitebark pine stands is being evaluated. Investigators are continuing the analysis of integrated approaches to protect these threatened habitats.

Obviously, more work is needed to develop successful IPM programs for protection of critical habitats. Most of the other priority topics being addressed by the Initiative will influence which individual tools are included in successful IPM programs. However, it is difficult to design truly integrated approaches and evaluate these inherently complex studies in a one-year time period.

Publications

Due to the variation in timing and nature of the projects, formal reports and publication of findings in peer-reviewed journals are in different states of completion. As of March 2006, four peer-reviewed publications have been produced, and three more have been submitted for review. Investigators have indicated that another 14 manuscripts and reports are in preparation.

Presentations

In addition to project results being presented at the 2004 and 2005 annual BBTWG meetings, numerous presentations were given at regional and national meetings. Presentation of results can serve as another means of technology transfer in addition to publications.

Other products and implementation

Project results from some studies are already being implemented in FY 2006. Examples include single-tree protection tools for cypress bark beetles in Arizona and a new version of the FVS Parallel Processing Extension that is used to link

the Westwide Pine Beetle Model, Fire and Fuels Extension, and GIS for landscape simulation of forest management.

Results of several projects need to be validated or further refined before additional products are generated or results are implemented. For example, determining optimal mixtures of bark beetle semiochemicals (including non-host volatiles) for survey and management of western bark beetles typically requires more than one year to fully validate results under a range of conditions (i.e., under different bark beetle population levels, range of stand and climatic conditions). However, results from such projects can serve as an important step in the progress of longer term accomplishment goals.

Distribution of Projects by Topic Area

To a large degree, funded projects were well-distributed across the ten priority topic areas generated by the BBTWG despite no emphasis to have a balanced distribution (***Figure 2***). Two topic areas (*B. Meaning of trap catches* and *E. Effectiveness of anti-aggregation pheromones*) were the most commonly studied. In contrast, three topic areas (*A. Management options in critical ecosystems*, *D. Interaction fuel mitigation work* and *J. IPM strategies for critical habitats*) were not as well represented. Several projects included multiple objectives and therefore addressed more than one research topic areas. For example, "*Evaluation of a verbenone / non-host volatile / trap-out strategy for protection of high elevation whitebark pine against mountain pine beetle attack*" by Bentz and others had implications on topic areas A., C., E., F., and J.

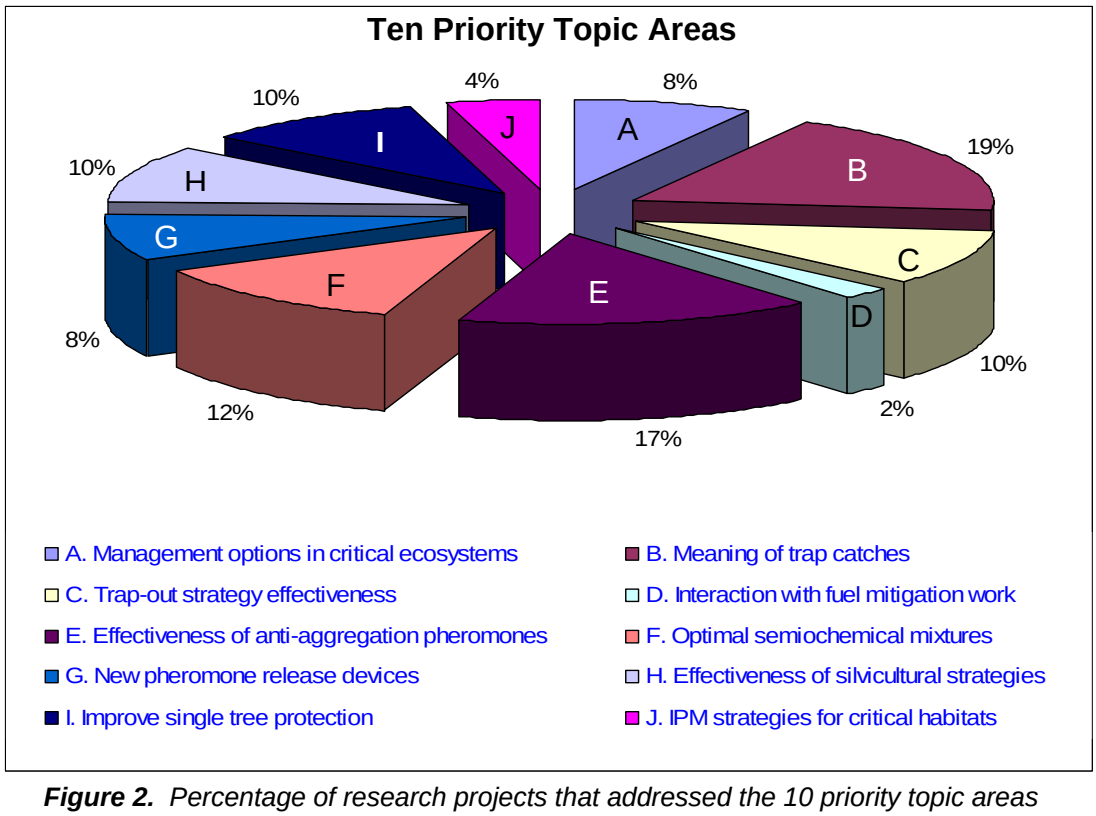

Figure 2. *Percentage of research projects that addressed the 10 priority topic areas identified in the Western Bark Beetle Initiative.*

The funded projects were evenly distributed across three of the four recommended research activities in the 2002 Western Bark Beetle Report, which was used as an initial guide in determining priority topics (Appendix I). The BBTWG was under direction from FHP and R&D Directors to not include a priority topic directly addressing the fourth activity area (*B. Clarify the results and interactions between bark beetle populations, wildfires, and prescribed fires*). Thus, only three projects directly or indirectly focused on the fire–bark beetle interactions, and these projects included other research objectives as well. In addition, direction provided by the Directors may have resulted in fewer projects examining the BBTWG topic area *D. Interaction with fuel mitigation work*.

What Topic Areas should still be Considered High Priority?

The fact that at least one project could be categorized in each research topic area does not imply that the topic area was adequately addressed or that it does not require further study. In-depth discussion by the BBTWG is required to assess which topic areas should be retained as high priority items for additional study. A new priority list will likely be generated through the creation of a 5-year action plan being developed by the BBTWG in 2006. Nevertheless, because topic area *D. Interaction with fuel mitigation work* was not directly investigated, despite repeated discussion of the widespread occurrence of fuel reduction treatments projects throughout the West; it should continue to be considered a high priority item. In addition, topic areas *A. Management options in critical ecosystems* and *J. IPM strategies for the protection of critical habitats* were only partially addressed, and therefore should be considered as high priority topics in the future. While topic area *D.* is more conducive to short-term, West-wide studies, topic areas *A.* and *J.* would likely require more complex, multi-year evaluations.

Evaluation of the Initiative

Regional FHP representatives and R&D funding recipients were asked to provide input on aspects of the Initiative, and whether the Initiative could be used as a model system for an accelerated collaborative effort between FHP and R&D. Listed below are comments that were received in regard to the conceptual design of the Initiative, the process of determining topic priorities and proposal selection, and collaboration and communication between FHP and R&D; they have been modified for clarity. These comments represent the opinions of those who responded and do not necessarily embody a majority viewpoint of the review panel.

Conceptual

- Dedicated pool of money that was to be used solely for bark beetle-related technology and methodology development. R&D has been increasingly reliant on soft dollars to fund projects, and having monies specifically ear-

marked for western bark beetles was good. Because there has been a recent lack of research funds, several needed studies would not have been initiated without the Initiative.

- Specifically addressing the "accelerated" aspect of the Initiative; that emphasis reflects the on-the-ground fact that bark beetle activity has been unusually high in recent years across a broad geographic area. To the extent that beetle-caused mortality is "accelerated", it is good to have the option to respond in-kind.

- Initiative provided a mechanism for focusing R&D efforts and limited funds on the most relevant research needs for western bark beetle management. This resulted in focused applied research.

- Mechanism for rapid assessment of initial trials of potential bark beetle management tools.

- WBBI was successful in accelerating research programs by providing funds to complete necessary steps in development of potential bark beetle management tools.

- Filled short-term funding to complete long-term studies. Without such funding, it may have been difficult to obtain necessary funds to finish projects. It also provided incentive to complete the study and transfer results to natural resource managers.

- Allocation of funds from FHP to R&D was expedited by transferring the funds directly to each Research Station instead of through FS Regions. Also, these funds were more flexible than, for instance, STDP funding by allowing for maintenance of budget by one Principle Investigator (PI).

- Funded projects that can produce an output in a short time frame without collecting multiple years of data to get to the same answer are needed. The requirement for reporting or some type of product in one year resulted in an expedited technology transfer process to the field.

- Windfalls of money in a short time can actually be counterproductive to the completion other ongoing research projects. For instance, other studies that were initiated prior to the start of the WBBI received less than adequate attention.

- Potential valuable bark beetle management tools may be abandoned after only the first attempt. Often the first approach selected to address a potential management tool is *not* the best and there was no time to correct. If multiple years of funding were available, more efficient designs or methods could be developed.

- Applied research requires knowledge of the biology/ecology of the organism/system in question. Future projects should be afforded the flexibility to investigate basic biological topics even where the emphasis is toward the applied.

Process

- The process of developing priority topics was generally well received. For example, it was valuable to openly exchange ideas regarding knowledge gaps and research needs. The request for a "laundry list" of priority research topics required the BBTWG to focus on what was truly needed and practical to accomplish. The final list of priority topics is reflective of FHP needs for better bark beetle management. Input from National Forest System may strengthen the process even more.

- The process of having one FHP representative from each Region to evaluate proposals, evaluate projects and allocation of resources went reasonably well. It was a process that would withstand scrutiny of individuals with a vested interest in the outcome of the rated projects.

- One-year time frame was problematic because many of the priority topics require multiple years of study to fully understand how management tools and strategies will work under diverse ecosystems and varying bark beetle populations. In addition, the initial discussion of priority topics was constrained because only short-term projects could be considered. In the future, a similar discussion that considers long-term projects would be productive.

- Request for Proposals was distributed near the end of the calendar year, when many people were on annual leave. Given the quick turn around needed for submission of proposals this was less than optimal timing. Short turn around time for submitting proposals also provided less than adequate time to develop better projects of mutual interest.

- RFP needs to more clearly state the instructions, selection criteria, and expectations for products. For example, was funding limited to R&D scientists only?

- Proposal review panel was comprised of only FHP personnel. Should have included R&D scientists or external entomologists on the panel to review proposals and evaluate projects.

- Process for selection of proposals to be funded seemed opaque and arbitrary. Writing proposals is a huge effort, and feedback should be given, especially for those not selected.

- Rocky Mountain Research Station (RMRS) Assistant Directors ranked proposals submitted by RMRS scientists prior to sending proposals to the FHP review panel. This shortened the time frame for preparing proposals even more. Further, it added no value to the process. It was not requested by FHP, and the review panel did not use RMRS rankings in making decisions.

- There were delays in getting the RFP's distributed from the WO Research Staff offices to the FS Research Stations.

- Future Initiatives would benefit greatly from increased flexibility of funding expenditures. Funds were obtained in the spring and had to be spent by September 30 of that year, which makes it difficult to plan, design, execute and complete a technology development project.

- Not all money allocated was awarded in the second year of the program, despite there being a number of worthy projects. More open communication is needed. If there are specific concerns with a proposal, the PI could be contacted with questions/issues of concern. Funds are scarce, and to have money that has been specifically allocated for bark beetle technology development turned away sets a bad precedent, not to mention loss of important study that would have been focused on bark beetles.

- Certain projects would not be able to successfully complete targeted objectives within the specified one-year time frame. Need to make sure everyone abides by the same rules. Also, a few proposals were not applied research and would not deliver products useful to resource managers.

- Some projects are still in analysis paralysis, and it is uncertain when the final results or products will be delivered. Some researchers received additional funding in FY05 when their FY04 projects had not been completed.

<u>Collaboration and communication</u>

Because the RFP stated that all proposals must have both a FS R&D scientist and a FHP entomologist, in theory, the Initiative should result in increased collaboration between FHP and R&D. There were many cases of positive, constructive interaction, and state and university collaborators were often involved as well. For example, the two WBBI funded studies on spruce beetle in Alaska confirmed the cooperation FHP and R&D have had in Alaska for the past 30 years. Without this cooperation, few products would have been produced for understanding and managing forest stands susceptible to infestation by spruce beetles. The limited number of FHP and R&D personnel makes it necessary to cooperate in order to accomplish our long-term goals.

On the other hand, there appeared to be negligible interaction in some instances. For example, it was observed that some proposals had been submitted with a FHP sponsor's name; however, the sponsor had not been contacted by a R&D scientist prior to proposal submission nor did the sponsor have a chance to provide input. In such cases, the opportunity for constructive interaction was constrained.

Because both FHP and R&D contributed to the development of priority topic areas, this process was well-received. Additional refinement at subsequent BBTWG meetings can work to further define the priorities that should to be addressed to meet the needs of FHP and land managers.

There was a general feeling among FHP representatives that the proposal review process went well and that each Region had a say in what transpired. Some researchers questioned the protocol of reviewers recusing themselves from rating a proposal if their name was on the proposal and using the average rating of remaining reviewers. However, that process expedited the final rating of proposals by not having to find new reviewers whose names were not on a proposal. Others have suggested that R&D research entomologists should be included in rating of proposals. Because FHP provided funding for this Initiative, however, it is recommended to keep the review panel solely comprised of FHP representatives. Other funding programs, such as the STDP, that include a combination of FHP and R&D monies, have proposals evaluated by both FHP and R&D. Research entomologists contributed greatly to developing priority topics and assessing the program.

Both FHP and R&D need to be involved to increase the level of the communication and interaction. The level of constructive interaction could be increased by holding pre-proposal meetings to determine priority items that are important to a particular Region(s), priorities that are of interest to scientists, and priorities that scientists have expertise in. Such meetings would also help to ensure that proposal requirements are followed and that there are clear expectations of what will be done and when. In addition, the RFP needs to plainly state the proposal rating criteria, and what is expected in terms of suitable products. Timing of RFP and proposal due dates may have limited these types of meetings from occurring, i.e., RFP for FY2004 was sent to Stations in December and proposals were due in January. Nonetheless, everyone should work toward increasing the level of communication and collaboration.

Conclusions and Future Recommendations

The primary goal of the Western Bark Beetle Initiative program was to accelerate development of tools needed to minimize impacts of bark beetles to forests in the western US. To assess the overall quality of this program, the following questions need to be answered: Have tools for managing bark beetles been improved? What can be done differently, or better, if additional funding is

allocated to a similar initiative in the future? Is this a program worth pursuing in the future? If so, how should the program proceed? The following paragraphs attempt to answer these questions.

As many Principle Investigators have not yet completed formal reports, published manuscripts, or developed management tools, it is premature to determine relative success of individual projects and overall effectiveness of the Initiative. As of January 2006, eight of the 27 projects (30%) still needed to complete evaluations or analysis of results. Most of these "in progress" projects were initiated in FY 2005 and the final assessments (did trees live or die?) will be conducted during 2006. Thus, benefits of the Initiative will likely not be fully realized for some time. Nonetheless, this program succeeded in several ways by 1) providing short-term funding (i.e., seed money) to evaluate the potential of new management tools, 2) allowing completion of a critical step in long-term development of a management tool, and 3) resulting in completion of a long-term study that would not have been funded otherwise.

Because *Interaction with fuel mitigation work*, *Management options in critical ecosystems*, and *IPM strategies for critical habitats* were not adequately investigated, they could be considered high priority topics for future accelerated technology development programs. However, the later two topic areas are impossible to fully undertake in one-year funding cycles. Results of a FHP representative survey indicate that the *Interaction with fuel mitigation work* and *Improvement of new single tree protection tools* topics be selected for future funding opportunities. Ultimately, which priority topics should be funded in the future depends on whether they are addressed in one-year funding cycles or multi-year studies.

The very nature of bark beetle biology does not easily lend itself to short-term projects. Because of this restriction, development of priority topics and submitted projects leaned heavily towards semiochemical work, including the meaning of trap catches. This is not a criticism of the original goals of the program. The BBTWG fully understood the restrictions imposed by the budgetary process. However, it may give the impression to "outsiders" that semiochemical work has greater potential than forest health workers would attribute to it. In addition, if the primary goal of long-term, economically viable bark beetle management is to be realized, more attention needs to be given to silvicultural-based and integrated management systems.

It is important to note that there are other funding mechanisms administered by the Forest Service for multi-year technology and methodology development of management tools for controlling western bark beetles (and other insects and diseases) and monitoring their impacts (e.g., STDP, Forest Health Monitoring Evaluation Monitoring). Investigators submitting proposals to these programs may request funding for a maximum of 3 years, but significant progress must be made each year to ensure funding in subsequent years. Several projects funded

by these programs have led to the advancement of bark beetle management tools. In contrast to these programs, WBBI provided a means for relatively fast funneling of monies toward technology development of native western bark beetles that threaten many forest resources throughout the western US. Additional alternative funding mechanisms that address long-term development of management tools should be explored.

While local or regional knowledge gaps still exist for various bark beetle/host systems in the western US, allocation of limited funds across a wide range of topic areas can lead to a dilution of efforts and resources. Perhaps a more efficient method would be to select only one or two high priority topics (i.e., interaction of fuel mitigation activities and bark beetles or new single tree protection tools,) and focus on them in a concentrated West-wide group effort. This would likely result in better standardization of protocols to test new release devices, testing of semiochemicals, elucidation of the meaning of trap catches, etc., across several beetle/host systems and over an array of stand and climate conditions, and beetle populations. Obviously, this would require more upfront planning, but such an effort could result in a superior accelerated technology development program. The evaluation of Onyx in preventing successful bark beetle attack is a recent example of a new product or technology that was evaluated West-wide.

Moreover, it is recommended to conduct workshops at Western Forest Insect Work Conferences, BBTWG meetings, or other venues to better synthesize the results of studies addressing similar research topics. For example, several studies investigated the meaning of funnel trap catches in terms of bark beetle populations and effects of anti-aggregation pheromones, including non-host volatiles, on reducing bark beetle attacks. Workshops that bring together investigators and cooperators involved on these topics could lead to increased synthesis of results and faster transfer of information to FHP and land managers.

In conclusion, the WBBI has been an effective means of prioritizing known technology gaps and allocating monies to address these gaps. Similar future programs should emphasize more upfront planning in coordinating FHP and R&D efforts to focus on selected priority topics. This should result in even greater efficiency of limited resources and acceleration of developing management tools.

Literature Cited

USDA Forest Service & Western Forestry Leadership Coalition. 2002. Western Bark Beetle Report: A Plan to Protect and Restore Western Forests. 7 p.

USDA Forest Service. 2005. Forest Insect and Disease Conditions on the United States 2004. USDA Forest Service, Forest Health Protection, August 2005. 142 p.

Appendices

Appendix I. Recommendations for accelerated research activities outlined in the 2002 Western Bark Beetle Report.

"The research proposed in this report focuses on developing approaches and methods to prevent bark beetle-caused mortality. The research activities emphasize the following areas:

A. Improve methods to predict where, when, and how much bark beetle activity will occur on a forest landscape

B. Clarify the results and interactions between bark beetle populations, wildfires, and prescribed fires

C. Develop additional technologies for using natural attractants and repellents such as pheromones to protect forest resources

D. Develop economical and environmentally-safe methods to selectively protect priority resource values on area-wide forest landscapes

These areas of emphasis will improve the ability to predict bark beetle epidemics and protect priority resource values across forest landscapes, and help develop forests that will be more resistant to wildfires and bark beetle outbreaks in the future."

Appendix II. Western Bark Beetle Initiative review panel.

One FHP entomologist from each of the western Forest Service Regions served on a WBBI review panel. Each of these representatives reviewed and rated proposals, made recommendations for funding, and evaluated project accomplishments. At the BBTWG meeting in Midway, UT (October 2005), it was decided that one research entomologist from each western Research Station should also participate in evaluating the program.

Forest Service Forest Health Protection

Ken Gibson
R1, Forest Health Protection

Tom Eager
R2, Forest Health Management

Joel McMillin
R3, Forest Health

Brytten Steed
R4, Forest Health Protection

Danny Cluck (2004)
R5, Forest Health Protection

Sheri Smith (2005)
R5, Forest Health Protection

Iral Ragenovich
R6, Forest Health Protection

Mark Schultz
R10, Forest Health Protection

Forest Service Research & Development

Rob Progar
Pacific Northwest Research Station

Chris Fettig
Pacific Southwest Research Station

Barbara Bentz
Rocky Mountain Research Station

Appendix III. List of Western Bark Beetle Initiative Projects funded in FY 2004.

PROJECT TITLE	**INVESTIGATORS**	**AMOUNT FUNDED**	**PRODUCTS / STATUS**
Forecasting western pine beetle-caused tree mortality based on trap catch	Fettig & Negrón (PSW)	$69,680	Published manuscript, other results pending
Improve single tree protection tools for preventing *Phloeosinus* bark beetle colonization of cypress and juniper in the Southwest	DeGomez & Clancy (RMRS)	$42,338	Manuscript submitted, findings have been implemented
Evaluating microencapsulated MCH beads for protecting Douglas-fir stands from Douglas-fir beetle attacks in Colorado	Negrón (RMRS)	$32,542	Results pending
Evaluating the susceptibility to mountain pine beetle in uneven ponderosa pine stands in the Black Hills	Negrón (RMRS)	$42,085	Results pending
Flight periodicity and population levels of the spruce beetle in Alaska as determined by pheromone-baited trap catches	Werner (PNW)	$33,850	PNW report in preparation
Determining the area of protection of Douglas-fir beetle pheromone-baited traps at low, moderate and high beetle densities	Progar (PNW)	$61,377	Manuscript in preparation
The effect of non-host angiosperm volatiles on the efficacy of verbenone for disrupting western pine beetle attraction to pheromone baited traps	Fettig & Huber (PSW)	$53,223	Manuscript published, additional manuscript in preparation
Can pheromone-baited traps reduce Douglas-fir beetle-caused tree mortality?	Ross, Wallin & Seybold (PSW)	$70,415	Report forthcoming
Interpreting Pheromone Trap Captures for Managing Mountain Pine Beetle	Bentz & Hansen (RMRS)	$59,587	Manuscript submitted
Efficacy of Sprayable Verbenone MEC's and Flakes for Individual Tree Protection	Gillette, Mehmel, Owen & Stein (PSW)	$52,000	Manuscript in press, additional tests in progress
Bark beetle catches in pheromone traps, tree mortality, and coarse woody debris	Negrón (RMRS)	$41,237	Results pending
Evaluation of a Trap-Out Strategy for Protection of High Elevation Pines Against Mountain Pine Beetle Attack	Bentz, Logan, Hansen & Vandygriff (RMRS)	$64,845	Manuscript in preparation
Integrated landscape analysis of insect risks and mortality associated with fuel treatment scenarios in the Blue Mountains	Ager, Hayes, McMahan & Smith (PNW)	$59,163	New FVS processing extension
Southwestern ponderosa and pinyon pine bark beetles: significance of pheromone trap catches and effectiveness of traditional silvicultural management strategies	DeGomez, Kolb & Clancy (RMRS)	$78,388	1 manuscript published, 2nd manuscript in preparation

Appendix IV. List of Western Bark Beetle Initiative Projects funded in FY 2005.

PROJECT TITLE	**INVESTIGATORS** (Station)	**AMOUNT FUNDED**	**PRODUCTS / STATUS**
Determine the effectiveness of thinning and fertilizing Lutz spruce to increase resistance to spruce beetles in south-central Alaska	Werner, Hard, Youngblood & Schultz (PNW)	$28,860	PNW report in preparation
Thinning guidelines to prevent ponderosa pine bark beetle outbreaks in the Southwest	Wagner, Hofstetter & Edminster (RMRS)	$36,354	Manuscript in preparation
Non-host angiosperm volatiles and verbenone for disrupting western pine beetle: attraction to pheromone-bainted traps and trees	Fettig, Huber & Sullivan (PSW)	$49,184	Final evaluation to be completed in 2006
Systemic insecticide injections for protection of western conifers from bark beetles	Fettig & Grosman (PSW)	$30,304	Evaluation to be completed in 2006
Evaluation of the antiaggregant verbenone and application strategies in management of western pine beetle (WPB) in old-growth ponderosa pine	Hayes & Wakarchuk (PNW)	$56,050	Manuscript in preparation
Use of verbenone and non-host volatiles to reduce engraver beetle attack on ponderosa pine slash in Arizona	DeGomez & Edminster (RMRS)	$57,243	RMRS report in preparation
Evaluation of a verbenone / non-host volatile / trap-out strategy for protection of high elevation whitebark pine against mountain pine beetle attack	Bentz, Hansen, Vandygriff & Schen (RMRS)	$65,460	Manuscript in preparation
Drift resulting from ground applications of insecticides to individual trees	Fettig (PSW)	$20,000	To be completed in 2006
Flight temperature thresholds for Southwestern ponderosa pine bark beetles	Hofstetter, Wagner & Edminster (RMRS)	$15,294	Manuscript in preparation
Verbenone test to reduce mountain pine beetle attack of lodgepole pine in Region 1 & 4	Progar (PNW)	$49,372	Manuscript in preparation
Influence of host volatiles as pheromone lure synergists for southern pine beetle and western pine beetle in Arizona	Hofstetter, Wagner & Edminster (RMRS)	$65,319	Manuscript in preparation
Evaluating microencapsulated MCH beads for protecting Douglas-fir stands from Douglas-fir beetle attacks in Colorado	Negrón (RMRS)	$40,406	Results pending
Bark beetle catches in pheromone traps, tree mortality, and coarse woody debris	Negrón (RMRS)	$57,210	Results pending