Plan of Work for
The Areawide Management Evaluation of Melaleuca quinquenervia (TAME Melaleuca)

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THE AREAWIDE MANAGEMENT EVALUATION OF MELALEUCA QUINQUENERVIA: TAME Melaleuca

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Project Summary

Melaleuca quinquenervia (common name melaleuca) is a myrtaceous tree of Australian origin that has become a noxious weed in Florida. First introduced into this country by horticulturists in the late 1800's, melaleuca remained innocuous for nearly half a century. More recently, however, melaleuca has proliferated and now occupies approximately 200,000 ha of agricultural, riparian and wetland systems. This invasive tree is competitively superior to many native plants and rangeland grasses with infestation resulting in degradation of native wildlife habitat and of the limited grazing lands in south Florida. In addition, melaleuca degrades vital waterways that significantly contribute to fisheries productivity, act as nursery sites for fish and crustaceans, regulate run-off quantity and quality, mitigate flooding, and control erosion. Nearly $25 million has been spent over the past decade in managing melaleuca infestations, yet the weed continues to proliferate, particularly on private lands.

The control of invasive plants such as melaleuca is essential to the conservation and expansion of native species. Melaleuca control is therefore integral to the Comprehensive Everglades Restoration Plan (CERP) objective of achieving restoration and sustainability of south Florida's natural ecosystem. The Melaleuca Management Plan, developed by the interagency Melaleuca Task Force in accordance with CERP, recommends the integration of multiple control approaches, with an emphasis on biological control, as the most effective method for long-term, sustainable management of melaleuca.

The TAME Melaleuca project will demonstrate for state, federal, and private land managers the practical, integrated weed management strategies outlined in the Melaleuca Management Plan. Demonstration sites will be established in varied habitats within the geographic distribution of the weed where public and private landowners are highly motivated to manage melaleuca.

Specific objectives outlined in this plan of work include: 1) an operations phase to demonstrate the integrated strategies; 2) assessments of melaleuca's geographic distribution, impacts of control tactics and socio-economic factors associated with current and proposed control tactics; 3) supporting research that focuses on impacts of control tactics on the weed, interactions among biological control agents, and non-target effects of tactics; and 4) technology transfer. The goal of this project is to develop a sustainable and integrated melaleuca control program through partnerships with federal, state, local, and private land managers for the long-term control of this invasive weed.

Key Words: *Melaleuca quinquenervia*, weed, Everglades, biological control, Integrated Pest Management

Melaleuca Impact Statement

Melaleuca quinquenervia (Cav.) S. T. Blake (Myrtaceae), the broad-leaved paperbark tree, also commonly known as melaleuca, is a large, native-Australian tree (25-30 m tall). It occurs naturally within a 40-km-wide zone along the eastern coast of Queensland and northern New South Wales (11-34^{o} S). First introduced into the United States by horticulturists in the late 1800's, melaleuca remained innocuous for nearly half a century. More recently, however, melaleuca has proliferated and now occupies approximately 200,000 ha of agricultural, riparian and wetland systems. This invasive tree is competitively superior to many native plants and rangeland grasses with infestation resulting in degradation of native wildlife habitat and of the limited grazing lands in south Florida. Melaleuca invasion has transformed graminoid-herbaceous wetlands, including portions of the Everglades National Park, into closed-canopy swamp forests. These melaleuca swamp forests typically form dense monocultures characterized by a sparse understory. The increased structural diversity associated with these melaleuca savannahs temporarily results in increased biodiversity, but diversity is drastically reduced during later stages of invasion after displacement of native vegetation (O'Hare and Dalrymple, 1997). In addition, melaleuca degrades vital waterways that significantly contribute to fisheries productivity, act as nursery sites for fish and crustaceans, regulate run-off quantity and quality, mitigate flooding, and control erosion.

Economists and ecologists estimate the value of services provided by wetlands to be worth $14,785 per ha per yr (Costanza *et al.*, 1997). Assuming minimal losses comprising only 1% of these services arising from current melaleuca infestations (ca. 200,000 ha; Schmitz *et al.*, 1997), the lost value would total nearly $30 million *per year*. Furthermore, melaleuca is continuing to invade new areas causing accelerated degradation of wetlands. Infestation levels reported in 1994 were attained in less than 88 years, so melaleuca has increased at an average rate of 2,250 ha per yr or approximately 6.2 ha per day. Assuming a continuous linear rate of change and 100% decrement of wetland functions due to infestation, potential added losses could be as high as $33.3 million per yr. The South Florida Water Management District alone spent nearly $11 million to control this tree during 1991 to 1997 (Laroche, 1998), and estimates of losses to the local economy range as high as $168.6 million per year (Diamond, 1991). It is obviously very important to reduce the invasive potential of melaleuca while simultaneously eliminating existing stands.

Control of invasive plants such as melaleuca is essential to improving native plant and animal species abundance and diversity, which is integral to the Comprehensive Everglades Restoration Plan (CERP) overall objective of achieving restoration and sustainability of south Florida's natural ecosystem. The Melaleuca Management Plan (Laroche, 1994), developed by the interagency Melaleuca Task Force, recommends the integration of multiple control approaches, with an emphasis on biological control, as the most effective method for long-term, sustainable management

of melaleuca. Implementation of the plan by participating public agencies over the past decade has reduced by one third the acres of south Florida public land covered by melaleuca (Laroche, 1999). Even though the plan serves as a framework for management of all natural areas infested by melaleuca, the means to implement its recommendations on an areawide basis, including private lands, have been lacking.

We intend to demonstrate to federal, state, local and private land managers the integration of effective weed management strategies, as already outlined in the Melaleuca Management Plan, in order to promote further areawide adoption and integration of the plan on both public and private lands. Information gathered from demonstration sites, assessment efforts and research will be synthesized to develop a decision matrix that will aid end users in selecting the most appropriate tactics for their specific sites.

Current Melaleuca Control Tactics (adopted from the Melaleuca Management Plan)

Herbicides

Currently, herbicidal control is considered the most practical method of limiting the further expansion of melaleuca on state and federally owned lands. Labor intensive, manual herbicide applications to individual "outlier" trees and small tree stands continue to be an effective small-scale control throughout south Florida. Large-scale, labor-conservative aerial applications have been adopted on some publicly owned lands but concerns regarding marginal persistence times and significant effects on native vegetation may limit further adoption of aerial treatments when broadly applied. Such affordable large-scale herbicide applications, could, if deemed environmentally acceptable, further melaleuca management in south Florida. However, perpetual control hinges upon the integration of this approach with other tactics that aid in the suppression of new seedlings.

Mechanical

Mechanical removal using heavy equipment is not appropriate in most natural areas because of disturbances to soils and non-target vegetation. However, this method of control is used regularly along canal, utility rights-of-way and other similar areas adjacent to infested lands. Mechanically damaged stumps left after the operation produce copious amounts of root sprouts and re-growth from lateral vegetative buds. Development of re-growth requires regular follow-up treatments. Currently, felling trees in place and manual removal of melaleuca seedlings are the only forms of mechanical control being used. Hand pulling of trees is generally restricted to trees less than two meters in height. Mowing is implemented in some rangeland areas to improve grass competition.

Physical (Fire)

Woody vegetation can be stressed, or sometimes killed, by environmental alterations such as fire. Results from a research project conducted by The Nature Conservancy (Myers and Belles, 1995) suggest that fire alone is not adequate for control of mature melaleuca trees. This is not an unexpected conclusion as melaleuca's ability to rejuvenate after fire is legendary. Recovery of melaleuca stands after fire and post-burn seedling establishment and growth were too rapid for short-interval burn cycles to have any lasting impact.

Biological Control

Classical weed biological control is a relatively new addition to the compliment of control tactics. This technique involves reuniting an invasive weed with its coevolved natural enemies. In 1997, the Australian weevil *Oxyops vitiosa* was introduced and subsequently established in melaleuca dominated regions of Florida (Center et al. 2000). The Australian psyllid *Boreioglycaspis melaleucae* has been approved for release in Florida and is in the process of being introduced as well. Feeding by *Oxyops* adults and larvae damages meristematic tissues, immature leaves, and flower buds. Feeding by *Boreioglycaspis* nymphs and adults causes tip die-back. Both insects thus interfere with stem growth and reproductive success (Pratt et al. unpublished data). Because these weevils attack vegetative re-growth and severely impact seedlings, integration of biological control agents with other tactics (listed above) may reduce, if not eliminate, the need to do follow-up treatments.

In addition, inoculative releases of native pathogens that infest melaleuca in the United States have also been assessed (Rayachhetry 1998). Although their use has received less attention, pathogens may also be incorporated with current control tactics.

The Problem

An integration of all available control techniques will be required to effectively manage melaleuca in agricultural, urban and natural areas (Laroche 1994, 1998). Currently, mechanical control has been limited, for the most part, to felling trees on site and manual removal of seedlings in natural areas. Similarly, chemical control efforts have focused on the examination of herbicide methodologies. Controlled burns must be carefully planned and timed, and most likely require follow-up treatments. The biological control agents *Oxyops vitiosa* and *Boreioglycaspis melaleucae* suppress small seedlings and significantly damage vegetative re-growth, but their integration with these other approaches has not been demonstrated to public and private land managers.

The Goal

The goal of the TAME Melaleuca project is to demonstrate the effectiveness of an integrated approach for the control of melaleuca to be applied in the invaded habitats in the United States and beyond. This project represents an areawide demonstration of multiple control tactics in various combinations and their combined effectiveness. Private and public land managers will have an opportunity to see different strategies in real-life settings, and adapt techniques to address their site-specific melaleuca problems.

TAME Melaleuca

TAME Melaleuca consists of five interlacing components: demonstration, assessment, supporting research, technology transfer, and program management.

Demonstration

Objective: To demonstrate and publicize the effectiveness of an integrated approach for the areawide control of melaleuca that can be applied to invaded habitats in the United States and beyond.

Plan of Work: Melaleuca is widely distributed in Florida and invades lands with a variety of habitats and uses. Our program is therefore provided with ample localities on which to demonstrate melaleuca management alternatives. Demonstration sites will be selected so as to represent the range of habitat, location, and uses of land invaded by melaleuca. Included will be eastern and western locations; habitats that are permanently flooded, seasonally flooded and predominately dry; and land used for agriculture/grazing, wildlife habitat, and recreation. Associated with a variety of sites are expected to be a variety of land owners/managers whose participation in TAME will promote awareness of the project and its successes throughout the multi-faceted south Florida land management community. Site requirements are further delineated in the Request for Demonstration Sites (http://www.weedbiocontrol.org/melaleuca/index.html).

Assessment

Objective: To document the extent and location of melaleuca infestations, to compile baseline data against which to compare vegetation changes during the project, to monitor and assess the effects of management strategies at demonstration sites, and to assess cost versus realized benefits of the integrated approach.

Plan of Work:

Melaleuca Inventory: The development of effective and coordinated noxious weed management strategies at the national, regional, and local level depends upon accurate information concerning the extent, distribution, composition, and dynamics of populations of the problem species. This project will therefore develop a GIS/GPS database of the locations and extent of current melaleuca infestations. Preliminary studies have shown that Florida populations of melaleuca consist of more than one distinct chemical race, and suggest that biological control agent performance could be affected by these differences. Consequently, the chemical races present in infestations also will be identified. The South Florida Water Management District (SFWMD) conducts biannual surveys of melaleuca populations within their administrative boundaries, but surveys in other regions of Florida and elsewhere are lacking. USDA-ARS researchers and collaborators will document the location, extent, and composition of melaleuca infestations outside of the administrative boundaries of the SFWMD. Data collected will be combined with existing information in a GIS/GPS database that will assist in tailoring management strategies to each infestation. The data will also provide a baseline against which to assess changes resulting from management efforts. These efforts will be conducted during the first two years of the project, with follow-up surveys conducted in years 3-5.

Site assessments: Melaleuca management demonstration site assessments will provide instructive data for guiding future management decisions. Assessment will involve quantifying reductions in reproductive success, juvenile survivorship, plant size and recruitment of melaleuca as a result of different management strategies. Analysis of these data will be used to develop models to assist managers with creating site-specific management strategies. The models should allow land managers to contrast

potential outcomes with predictions of the investments (in terms of time, personnel, and expense) required to achieve those outcomes. Management procedures assessed will include (see Current Control Tactics above for additional detail):

- Biological control: Biological control agents (insects and pathogens) will be released in appropriate areas.
- Chemical (herbicides): Herbicides known to be effective in the control of melaleuca will be applied at label rates according to the best information from the manufacturer and the research community.
- Mechanical: Mowing of melaleuca stands can remove biomass and stimulate re-growth that is an ideal food source for the melaleuca weevil. Field observations also suggest that repeated mowing may cause death of a large portion of the mowed stems.
- Physical (fire): Fire does not kill mature trees, although it will destroy seedlings and young saplings. However, controlled burns result in seed release, nutrient release, and removal of the forest understory and soil litter. The resulting crop of seedlings, together with post-fire re-growth of mature trees, provides an ideal food source for the weevils.
- Combinations: Fire and insects; herbicides and insects; pathogens and insects; mowing and insects; pathogens, herbicides, mechanical and insects.

Site Sampling: At each demonstration site, prior to implementing a management strategy, the variation present in the existing plant communities will be characterized. Sampling points will be established within transects at each site and their locations recorded using GPS. Plant species composition and density will then be recorded within each transect. In each subsequent year of the study, sampling will be performed to monitor the impacts of management strategies. This may include estimation of realized and potential plant reproductive output and photo documentation of vegetation changes from established photo points.

Additional sampling will be performed at sites where treatments include release of biological control agents. Routine searches of each transect will involve counting insects and estimating feeding damage levels at randomly selected sub-sets of the sampling points to determine establishment, population expansion, and insect impact levels on target and non-target plants.

Socio-economic effects: Three socio-economic studies related to melaleuca will be conducted:

1) *An assessment of the macro-economic impact of melaleuca reduction*. Changes in the regional economy of Florida attributable to changes in the extent and intensity of melaleuca coverage will be evaluated. This may include impacts on public and private programs directed at melaleuca management and regulation, small businesses such as nurseries and beekeepers, utility land management costs, and economic uses of affected land. A no-control case and a status-quo (no net change in melaleuca coverage) will be included.

2) An evaluation of the costs and benefits of specific integrated control strategies. Programmatic costs and benefits will be evaluated for several prototypical environmental situations, and will include managed and natural habitats. Benefits will

be linked to the results of Study (1). Analyses of specific control strategies and combinations will serve as the basis for a computer-based economic decision model that will evaluate the least-cost and/or most profitable control strategies.

3) An evaluation of the adoption by land managers of the recommended strategies from Study (2). The ultimate success of this control project will depend on the extent to which management strategies are adopted by private land owners and public land managers. This study will include recommendations to improve the acceptability and implementation of selected control strategies by land managers. Data will be collected through interviews, surveys, and focus-group meetings.

Research

Objective: Whereas the impacts of control tactics and their integration on melaleuca populations will be examined as part of the Assessment component, the objective of the Research component is to examine more closely the biology of biological control agents and their impacts on growth and reproduction of melaleuca and non-target vegetation. Research updates will be provided annually, coinciding with publication of ARS annual reports.

Research Area 1: Impacts of biological control agents on weed reproduction
The objectives of this research are to: 1) evaluate the impact of defoliation by biological control agents on reproduction and growth of melaleuca and 2) quantify the impact of defoliation frequency on melaleuca reproduction and plant growth.

Research Area 2: Non-target impacts of biological control agents
The goal of this research is to quantify the quarantine-based predictions for non-target impacts by *Oxyops vitiosa* and other future agents on native plants. Specific objectives include: 1) surveying agent release sites for incidence of non-target damage on the native plants identified in quarantine as sub-optimal hosts and 2) quantifying the utilization of native, potential non-target plants in a common locality where agents have overexploited the surrounding melaleuca plants.

Research Area 3: Interactions among pathogens and insects
Interactions among the natural enemies potentially applied for melaleuca management will be studied. This includes synergistic and/or antagonistic interactions between and among pathogens and herbivorous arthropods.

Research Area 4: Pheromone attractants of the biological control agent *Oxyops vitiosa*
The goal of this research is to develop a pheromone-based monitoring system for *Oxyops vitiosa* in order to estimate field densities and distribution.

Research Area 5: Establishment and spread of biological control agents

In a manner similar to the successful release and assessment of *Oxyops vitiosa* (Center et al. 2000), release of the melaleuca psyllid will be followed by regular visits to demonstration sites and quantitative assessments of psyllid abundance. In addition, rates of spread of biological control agents will be measured within each plot. From this study we will evaluate optimal release strategies for biological control agents, assess site characteristics that influence establishment of populations, and ultimately establish self-sustaining field colonies.

Technology Transfer

Objective**:** To educate land managers and the public about integrated control methods for melaleuca, to encourage widespread adoption of these methods and to encourage continued application of integrated tactics for invasive weed management beyond the lifetime of the project.

Plan of Work: Education, outreach, and technology transfer are major components of any successful integrated weed management plan. Technology must be transferred to ensure widespread and long-term adoption. Field tours and other presentations will show attendees the impacts on melaleuca of integrated management tactics. Published and electronic informational materials will extend that information to a wider audience, and will serve as a more permanent resource for continued adoption of integrated management techniques for melaleuca as well as other invasive weeds in the future. Methods of educating our clientele concerning this program will include, but are not limited to:

1) Field tours: Frequent field tours and demonstrations (particularly in Years 3-5) will allow land managers to see firsthand the effects of different weed management strategies. Hands-on training can be incorporated into the tours. Explanations and discussions will further inform participants.

2) Video/photography: The demonstration areas will be systematically videotaped and photographed annually to document vegetative changes. This visual archive will be used to supplement oral presentations about the project at meetings, conferences, and symposia held outside the project area.

3) World Wide Web: A melaleuca homepage on the World Wide Web will be developed and maintained. This page will provide a brief description of the project, a description of ongoing research, recent research results, information on upcoming events, and links to associated WWW sites.

4) Symposium: An annual symposium will be held in conjunction with the Annual Exotic Plant Management Workshop (sponsored by The Fish and Wildlife Service). This meeting is well attended by public and private land managers and provides an ideal setting for updates on research findings and program developments. Organizers are among the collaborators of this proposal and have pledged their support.

Program Management

Objective: To coordinate the work of all involved agencies, organizations, and individuals; to keep records, produce timely reports, and organize the information

produced by the project; to coordinate technology transfer efforts; to promote continued cooperation of the partners in the management of invasive weeds; and to promote the concepts of integrated management applied here to melaleuca as applicable to invasive weed management in general.

1) Project coordinator: A project coordinator will be designated to facilitate the TAME Melaleuca program. Good communication is essential to the successful coordination of the many facets of this program. The Project Coordinator will be responsible for this task.

2) Oversight committee: An oversight committee comprising representatives from collaborating agencies and organizations will be established. This committee will advise the principle investigators (ARS and SFWMD) as the TAME Melaleuca program is developed, review site-specific action plans and assist in the implementation of critical program components. Specific responsibilities include hiring project coordinator; selecting demonstration sites and developing site management plans; meeting biannually to review progress, including review of progress reports from participating investigators; and budget approval for upcoming years.

Partnership and Collaboration

Individuals from a variety of federal, state, and local organizations participated actively in writing or steering the TAME Melaleuca Project. In addition to these cooperative relationships already established, a coordinated, grassroots effort will be mounted to communicate with and educate all affected parties about opportunities to join this project. Town meetings will be held, an informational letter, and follow-up phone calls will be used to invite people and their agencies to participate. Many face-to-face contacts have already been made and all have shown interest and enthusiasm for the idea of managing melaleuca in a large-scale project.

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