Laroche Agribusiness Consultants, LLC.

Recommendations For Melaleuca Control in French Guiana

François B. Laroche, MS., Executive Director, Laroche Agribusiness Consultants, LLC.

Stephen Enloe, Ph.D. Associate Professor, University of Florida.

October 2, 2019

1- CONTEXT

While it is true that plant invasions of most critical concern to resource managers are those that involve non-indigenous species, it is also true that mitigation is best accomplished if infestation are addressed in their infancy. Non-indigenous species infestations dramatically change the rate and direction of succession, alter in a fundamental way the physiognomy of vegetation and cause a corresponding decrease in richness of indigenous species. The invasion of natural areas by invasive non indigenous plants presents a critical impediment to the preservation of native biodiversity. While eradication of harmful alien species (Kowarik 1995) is desirable it is oftentimes impractical, especially when the invader has become widespread. In such instances, a comprehensive regional strategy employing an integrated pest management (IPM) approach to regulating populations of a nuisance plant can aid managers in allocating resources and coordinating efforts to optimize results. Considerable management effort aimed at modifying plant invasion has concentrated on plant control measures and on the success of such measures in achieving reductions of non-indigenous plants. A recent example from Florida is the successful management of the notorious Everglades invader Melaleuca quinquenervia (Cav.) S.T. Blake.

Melaleuca quinquenervia (melaleuca) is a fast-growing evergreen tree native to eastern Australia, it occurs naturally throughout Queensland, New South Wales, New Caledonia, and southern New Guinea (Blake 1968, Craven 1999). In Australia, it occupies flooded riverine sites and seasonally flooded sites behind coastal mangroves and dunes. Blake (1968) recorded cultivated specimens from South America (Guyana, French Guiana), Africa (Uganda, Senegal, Madagascar), and Asia (Hong Kong, Taiwan). It also is cultivated in Benin, Egypt, and the Bahamas (Gifford 1945). Confirmed United States collections include specimens from California, Florida, Hawaii, Louisiana, Texas, and Puerto Rico (Morton 1966, Blake 1968, Little et al. 1974). Melaleuca was introduced into southern Florida several times in the early 1900's. Scientific names under which M. quinquenervia was imported into the United States include: Metrosideros quinquenervia Cav., Melaleuca leucadendron (L.) L., Melaleuca viridiflora (L.f.) Byrnes, and Cajeputi

leucadendra (Stickm.) Rusby. Common names for M. quinquenervia include melaleuca, **niaouli,** paperbark, broad-leaved paperbark, five-veined paperbark, broad-leaved tea tree, Belbowrie, punk tree, and cajeput (Meskimen 1962, Morton 1966, Blake 1968, Boland et al. 1984, Craven 1999).

Melaleuca, traditionally known in Florida as the punk tree, encroaches upon a variety of habitats: freshwater marshes (including sawgrass prairies), cypress swamps, pine flatwoods, hardwood hammocks, salt marshes, mangrove forests occasionally), and is particularly prominent along ecotones (Myers and Ewel 1990). During early stages of invasion, the presence of M. quinquenervia fosters increased structural diversity in herbaceous marsh communities which results in an associated increase in wildlife diversity (O'Hare and Dalrymple 1997). The ultimate outcome of invasions, however, is replacement of native habitat by dense M. quinquenervia forests with drastically reduced biodiversity (Austin 1978, O'Hare and Dalrymple 1997). Such transformations threaten the biological integrity of Florida's Everglades ecosystem (Mazzotti et al. 1997), which has been a World Heritage Reserve, and a Wetland of International Importance (in 1987) (Maltby and Dugan 1994).

The lack of predators and pathogens, in combination with its numerous adaptations to South Florida's environment, significantly increases melaleuca's invasive potential. In a short time, the plant spread beyond the areas where it was intentionally planted. By 1970, melaleuca was established throughout the Everglades and by 1993 infested an estimated 200,000 hectares of wetlands in southern Florida (Laroche 1998). Large tracts of the Everglades River of Grass were quickly changing from sawgrass marsh and open water sloughs to dense melaleuca stands with little to no native plants in the understory (O'Hare and Dalrymple 1997).

Mounting evidence that melaleuca was causing substantial impacts to Florida's natural areas, led state and federal agencies to take action in the late 1980's against the spread of melaleuca and attempt recovery of impacted ecosystems. At that time, natural resource managers faced significant obstacles to melaleuca management. In particular, there were very few established control tools, there was no dedicated funding for control or research, melaleuca could still be legally cultivated and sold in Florida, and the public was largely unaware of the plant's harm to Florida's natural areas. Early in 1990, the Florida Exotic Pest Plant Council (FLEPPC) and the South Florida Water Management District jointly convened a task force of federal, state, and local land managers, scientists, and others to develop a plan for managing melaleuca. University of Florida scientists were a vital part of this task force in the research and development of herbicide control methods for melaleuca. The resulting Florida Melaleuca Management Plan (FLEPPC Laroche 1999) became a guiding document for a regional, comprehensive strategy.

Florida's eventual response to this long-neglected invasive species problem is an exceptional example of cooperative implementation of a comprehensive, long-term strategy. The Florida Melaleuca Management Plan and the initiatives it inspired can serve as a model framework for French Giana.

Important lessons learned through the process of implementing the Florida Melaleuca Management plan include:

Develop a region-wide strategy and maintain a commitment to interagency cooperation and information exchange;

Follow an integrated management approach — utilize multiple control tools and strategies (including regulatory initiatives);

Ensure consistent and sufficient financial resources — reliable funding greatly improves program efficiency through longer term strategic planning

Fund outreach and education — increasing public awareness improves prevention initiatives and strengthens support of agency programs.

Melaleuca along with Acacia mangium have been identify as two species of concern in French Guiana. Melaleuca is a major threat to coastal wetlands (swamps, flooded savannas), although its distribution is still limited. Melaleuca was introduced to French Guiana in the 80's for the opening of a paper mill market and is currently mainly extended to coastal wetlands. A protocol of effective control methods against this species is essential for the preservation of these coastal wetlands. Development of a melaleuca management program similar to Florida's program is recommended.

2- RECOMMENDATIONS

Management Plan -

The development of a Melaleuca Management Plan to provide objective criteria to determine suggestions for the integrated management of melaleuca in Guiana is recommended with the following objectives:

1- Eliminate melaleuca infestations from Guiana's natural ecosystems.

2- Achieve an overall reduction of melaleuca throughout Guiana such that maintaining Guiana's natural areas melaleuca-free is economically feasible

3- Implement an effective public information awareness and participation program that will encourage support for and participation in melaleuca management issues

4- Educate lawmakers and the public to develop legislation that restrict transport and cultivation of melaleuca

5- Ensure enough resources are focused on maintaining the areas where melaleuca has been removed free from new infestations

Early Detection and Rapid Response -

Considering that the melaleuca infestation in Guiana are not as extensive as in Florida, the establishment of an early detection and rapid response (EDRR). An EDRR program with the assistance of local experts' knowledge of indigenous biodiversity, can be valuable in halting the expansion of the infestation.

Ecological Studies

Ecological studies to further assess how melaleuca behaves in French Guiana may be beneficial to further understand it's invasion potential. These studies can aid in determining the best management approach for melaleuca. The tree mostly spreads by seed; therefore, understanding seed dynamics will be important for the management of this species.

Implement an integrated management approach

One of the keys to a successful invasive plant control program is the use of an integrated pest management approach. This approach combines control methods for greater effectiveness. Tools for controlling invasive plants are well developed and widely utilized although their application in natural areas has limitations. Researchers continually refine these control methods to be more effective in natural areas. These control methods include biological, mechanical, cultural, and chemical application.

Biological Control -

Biological controls include the use of living organisms, such as predators, parasitoids, and pathogens. "Classical" biological control seeks to locate host-specific pests from the plant's native range and import these species to attack and control the plant in regions where it has become invasive. For example, the alligatorweed flea beetle (*Agasicles hygrophila*) was introduced to North America in 1964 from Argentina to combat alligatorweed (*Alternanthera philoxeroides*). This insect continues to provide excellent alligatorweed control and has not caused damage to any other plants.

Four melaleuca insects have been identified and introduced as biological control agents in Florida. These agents have successfully established and are having significant results in reducing the rate of expansion of melaleuca. Guiana could benefit from these introductions by further investigating these biological control agents for introduction in Guiana. All biocontrol agents must be tested for years before they are released, and it may take many more years before the biocontrols build up effective populations to assist in control.

While biological control is not expected to eradicate melaleuca, reductions in melaleuca growth rates and reproductive potential can slow the rate of expansion and re-infestation of previously controlled areas, thus reducing herbicide control costs. Biological control is key to effective long-term management consequently the introduction of biological agent in Guiana can be a valuable tool.

Cultural Control -

Cultural control entails environmental alterations such as water level manipulation or fire. Environmental constraints often limit the usefulness of these methods. As melaleuca is a fire adapted species, and the spread of the tree is encouraged by fire, prescribed burning as a control tactic must be used with caution. According to Belle et al (1999) the most successful timing for prescribed burning is late wet season when the water level is at or near the surface to induce seed germination so the majority of burnt seedling will die during the ensuring dry season. A good ground cover is required to provide fuel load for a sustained burn. Prescribed burning is not effective once seedlings are greater than 3 to 6-month-old and above 10 to 20 cm. in height.

Flooding alone has not been shown to be an effective tool for the control of melaleuca as melaleuca seeds can germinate under water and seedlings and trees have the ability to withstand prolonged periods of inundation.

Mechanical Control -

Mechanical control is done with chainsaws, logging or heavy-duty equipment to clear trees. Mechanical removal using heavy equipment is not appropriate in most areas because of disturbances to soils and non-target vegetation. Stump left after mechanical removal must be completely removed or treated with herbicides to prevent root sprouts and regrowth from the cut surface. While costly, these methods are often used when other control techniques may cause unacceptable damage to native species or when removal of invasive plant biomass is necessary to achieve restoration objectives. Use of mechanical control may be limited to felling trees on site with chainsaws and manual removal of seedlings.

Chemical Control -

Chemical control includes the use herbicide to effectively control the target plant. Much of the effort in developing control measures for melaleuca in Florida have been in the examination of herbicide methodologies.

Herbicides are pesticides designed to control plants. Herbicides approved for aquatic use or in terrestrial natural areas are a vital component of most control programs and are used extensively for invasive plant management in South

Florida. There are over 20 herbicides employed to control invasive plants in South Florida.

Several herbicide products are very effective in the control of melaleuca in Florida however some of these products are not available in French Guiana. Unless these herbicide products are certified and approved by the French Government, it will not be beneficial to conduct studies with products that are not currently available. Therefore, available herbicides in Guiana must be evaluated to determine the effectiveness of these products.

The most effective herbicide solution for melaleuca control is a mix of Glyphosate and Imazapyr in a 50% solution with water (40% Glyphosate, 10% Imazapyr and 50% water). However, Imazapyr is not available in French Guiana. Although Glyphosate and Triclopyr are not as effective as Imazapyr at lower concentrations, these products have shown some effectiveness when used at higher concentrations. Glyphosate is available in French Guiana as RoundUp Innov and Triclopyr can be found in a mix with 2,4-D and sold as GENOXONE ZX E. Therefore, the use of these two herbicides using the hack and squirt method also referred to as frill and girdle, the cut stump treatment for mature trees and saplings, and foliar application for seedlings and saplings must be evaluated. Obtaining approved herbicides for melaleuca in Guiana and initiating research to refine herbicide application techniques will greatly enhance the overall success of a melaleuca control program. Careful selection and use of herbicides will result in the cost-effective elimination of melaleuca.

Glyphosate is a broad-spectrum, water-soluble herbicide that kills plants by inhibiting synthesis of amino acids. When applied to the leaves of plants or directly into the plants (as in cut surface applications), glyphosate translocate throughout the plant. Glyphosate is not absorbed by plant roots because it is adsorbed strongly once it comes in contact with the soil. Therefore, damage to non-target vegetation as a result of root uptake is minimal. Care must be used to avoid contact of the herbicide spray with the leaves and green stems of non-target plants.

Triclopyr affects many woody plant species and broadleaf herbaceous species but grass species are relatively tolerant to it. It kills plants by disrupting tissue development and other physiological processes. It is absorbed primarily through plant leaves and to some extent by plant roots. Damage to non-target vegetation as a result of root uptake is more likely in porous, low organic matter-containing soils. Triclopyr is manufactured as the amine salt (Garlon 3A, Renovate 3) or ester (Garlon 4, Pathfinder II). The amine salt is water soluble and the ester is oil soluble. Both the amine and ester are absorbed through leaf tissues, but a surfactant is necessary to aid uptake of the amine. Neither amine nor ester is absorbed effectively by melaleuca leaves without a surfactant.

Herbicide Application Methods -

Hack and squirt applications (also called frill and girdle) should be used for outlier trees and for large stands unless aerial application can be available in Guiana. Hack and squirt is much more labor intensive than aerial application but can reduce non-target damage. A machete is used to cut through the bark deep enough to expose the living tissue just inside the bark (cambium layer). Cuts are made in a downward direction, so the severed bark remains to contain the herbicide mixture. Pending results of studies conducted in French Guiana, herbicide concentrate or diluted in water at 50% can be applied to the girdle in sufficient quantity to thoroughly wet the tissue. A hand-held spray bottle is used to apply the herbicide.

Cut stump application is the most labor-intensive application method and is used primarily when it is not desirable, for reasons of safety or aesthetics, to leave dead trees standing. Trees, depending on size, should be felled with a handsaw, or chainsaw as close to the ground as possible and as level as possible to avoid run off of the product. Sawdust should be brushed from the cut surface before applying herbicide. Subsequent to results from studies conducted in French Guiana Herbicide concentrate or diluted in 50 % solution with water can be applied just inside the bark, where the living tissue of the tree is located.

Heavy machinery can be used to push down and uproot melaleuca trees in certain areas. However subsequent herbicide applications to control resprouts and resulting seedlings is necessary. Foliar applications of Glyphosate or Triclopyr or a combination of these two products can be used to suppress regeneration of tree stumps and small seedlings. This type of control method must be performed prior to the onset of the rainy season to allow stumps to resprout and seedlings to emerge prior to inundation of the area during the rainy season. Pending results of a demonstration study in French Guiana Seedling and saplings can be treated with either products diluted in water at 5% or 3 % as a low volume application, using a backpack sprayer. Small seedlings can also be hand-pulled but must be left hanging or put in a pile and sprayed with herbicide solutions as pulled seedlings left on the ground tend to resprout and form new plants. This treatment can also be replicated to further refine the results of this method.

Herbicidal control currently offers a practical and economically feasible method of limiting the further expansion of melaleuca in most areas. Therefore, the development of a melaleuca management strategy should be concentrated around herbicidal control, and limited use of mechanical and physical control

4- MANAGEMENT STRATEGY

A clear understanding of melaleuca's growth habit is important in developing a strategy for control. Trees grow quickly and readily re-sprout after being damaged. New trees take approximately 2 years to mature and produce viable seeds. Melaleuca is well adapted to fire and has a dense root system that adapt to flooded or dry conditions. With these advantages' melaleuca infestations can quickly develop into dense forest that displaces native vegetation. Effective melaleuca management requires knowledge of its biology. The reproductive potential of melaleuca is tremendous, in Florida it flowers multiple time per year and produces copious amount of seeds. A mature tree may retain millions of seeds, all of which may be released from their protective capsules following a stressful event such as desiccation, fire, physical damage, and herbicide application. Once released, 15 -20% of the seeds will germinate. However, the exceptionally small seeds do not remain viable for more than a year (Woodall, 1983). This relatively short period of seed viability limits the time for new seedling establishment. Hypothetically, melaleuca can be eliminated from an area in two years. The first year of control would target all existing trees and seedlings in a given area. Control crews would return to the same site in the second year and remove any seedlings resulting from the previous year's work, before they start producing seeds. Realistically, several years of monitoring and retreatments are required to eliminate melaleuca from a particular site in order to ensure that all seedlings are eliminated. Therefore, a strategy that aims at eliminating seed productions is essential.

The approach of melaleuca management should follow a quarantine strategy. The least infested areas are addressed first, in order to stop the progression of the existing population and create a buffer area between infested and pristine Areas. The goal of any management strategy should be to achieve maintenance control while minimizing impacts on non-target vegetation. Maintenance control means applying management techniques in a continuous basis to keep an invasive plant population at its lowest feasible level. Any control strategy must include follow-up treatment to eliminate new seedings before they can produce viable seeds.

Today, the melaleuca infestation in Florida is no longer increasing, in many areas it is being reduced. The operational and experimental work accomplished to date, demonstrates that melaleuca can be effectively and consistently controlled using an integrated management approach. However, the ultimate elimination of melaleuca in Florida will depend primarily on the future of availability of funds. Control operation should consist of three phases:

Phase I.

This phase focuses on the elimination of all mature trees and seedlings present in an area.

Phase II.

Previously treated sites are revisited for follow up treatment to control trees previously missed and remove seedlings which may have resulted from control activities of the preceding year.

Phase III.

This phase entails the long-term management of melaleuca, surveillance and inspection of previously treated sites to monitor the effectiveness of the melaleuca control program and maintain re-infestation levels as low as possible.

Management strategies should be revised as control methodologies are developed which improve efficacy and cost effectiveness.

5- CONCLUSIONS

It is of the utmost importance that French Guianese authorities recognize the crucial importance of dedicated follow-through on the issue of melaleuca control. Once a management program has been implemented, it is a necessity for the management effort to persist. Initial efforts to control melaleuca often induces the total release of seeds, and the subsequent spreading of, seedlings. Follow up treatment and continued surveillance and monitoring is critical for the success of the program. Otherwise treated areas left without follow up treatment will exacerbate the problem. Therefore, long-term allocations of resources and funding must be made available for any hope of continued control of the infestation.

The goal of the melaleuca management program should be to contain melaleuca populations from expanding and to maintain infestation levels as low as possible while minimizing impacts on non-target vegetation. The melaleuca management strategy should be based on the quarantine strategy described by Woodall (1981). The least infested areas are addressed first, in order to stop the progression of the existing population. The girdle and cut/stump application method of herbicide can be the primary tool used on mature trees. Melaleuca seedlings in mixed communities can be hand-pulled in an effort to minimize the impact of herbicides on non-target vegetation. Seedlings should be left hanging on remaining vegetation or put in a pile to reduce the possibility of regrowth. Broadcast applications of herbicides can also be used in areas of high seedling densities when non target damage is not a concern.

Imazapyr is the primary herbicide used for melaleuca control in Florida. This product is not available in Guiana thus, preliminary research must be conducted with available products in Guiana (Glyphosate and Triclopyr) to determine effective rates of applications. These two

products have been tested in the melaleuca program in Florida and have shown some promise.

Regardless of control method utilized, a comprehensive data collection and evaluation plan is essential for the success of melaleuca management initiatives. Record keeping is invaluable for making future management decisions. Data collection should include: longitude and latitude coordinates at each treatment site, date and time of control, type of control method, type of herbicide and amount, method of application, number of trees and seedlings or hectares treated at each site and, labor and equipment hours. These are used to produce maps of treatment progress and to keep track of melaleuca control sites.

Again, the uniqueness of melaleuca – including the fact that melaleuca trees are fire-adapted, whereby fire leads to dispersal of seedlings and the creation of ideal soil conditions for seedling establishment – necessarily means follow up treatment and continued surveillance and monitoring is critical for the success of any management program designed to address melaleuca as an invasive species.

The use of melaleuca for economic gain, such as the production of essential oils or biomass production, is not recommended and highly discouraged as the transport of trees alive or dead will further spread the infestation of melaleuca throughout French Guiana. Each tree contains millions of very small seeds; once the tree is stressed or cut it releases all its seed. Seeds will stick to equipment tires, tree bark, truck bed etc. and will be transported and infest other areas, especially along roadsides and water courses.

Laroche Agribusiness Consultants, LLC will remain available to assist in the implementation of a melaleuca management program in Guiana. Toward that end, a cooperative relationship should also be established with the University of Florida to collaborate on further investigations and the continuing development of more specific control methods unique to Guiana's melaleuca infestations. Investigations ino the possible introductions of biological control agents would likely also be beneficial for the long-term management of melaleuca in Guiana.

Additionally, a delegation of land managers and government officials from Guiana is encouraged to visit the South Florida Water Management District to review melaleuca control progress made in Florida and interact with agency professionals who have successfully implemented Florida's melaleuca control program.

Lastly, after visiting French Guiana, we have fortunately determined that contrarily to Acacia mangium the melaleuca infestation is in its infancy. Nevertheless, we strongly urge the French Guiana authorities to address this very serious issue as soon as possible. It has been demonstrated that when invasive plants are controlled in their early stages of encroachment, it is less expensive and much easier to bring the infestation under maintenance control.

6- REFERENCES

AUSTIN, D.F. 1978. Exotic plants and their effects in southeastern Florida. Environ. Conserv. 5:25–34.

BELLE, H. A., R. L. Myers and D. D. Thayer. 1999. Physical control, p. 29-31. *In:* F. Laroche (ed.). Melaleuca management plan, ten years of successful melaleuca management in Florida 1988-1998. Florida Exotic Pest Plant Council.

BLAKE, S.T. 1968. A revision of Melaleuca leucadendron and its allies (Myrtaceae). Contr. Queensland Herb.1:1–114.

BOLAND, D.J., M.I.H. BROOKER, G.M. CHIPPENDALE, N. HALL, B.P.M. HYLAND, R.D. JOHNSTON, D.A. KLEINIG, and J.D. TURNER. 1984. Forest trees of Australia, 4th ed. Thomas Wadsworth, Melbourne, Australia.

CRAVEN, L.A. 1999. Behind the names: the botany of tea tree, cajeput and niaouli. p. 11–28. In: Southwell, I. and R. Lowe (eds.). Tea tree: the genus Melaleuca. Harwood Academic Publishers, Amsterdam, The Netherlands.

GIFFORD, J.C. 1945. Living by the land. Glade House, Coral Gables, Florida.

KOWARIK, I. 1995. Time lags in biological invasions with regard to the success and failure of alien species. p.15–38. In: Pysek, P., K. Prach, M. Rejmanek, and M. Wade (eds.). Plant invasions: general aspectsand special problems. SPB Academic Publishing, Amsterdam, The Netherlands.

LAROCHE, F.B. 1998. Managing Melaleuca (Melaleuca quinquenervia) in the Everglades. Weed Tech. 12:726–732.

LAROCHE, F.B. 1999. Melaleuca management plan: ten years of successful Melaleuca management in Florida, 1988–98, 3rd ed. Florida Exotic Pest Plant Council, West Palm Beach, Florida.

LITTLE, E.L., R.O. WOODBURY, and F.H. WADSWORTH. 1974. Trees of Puerto Rico and the Virgin Islands, Volume 2. Agric. Handb. No. 449, U.S. Department of Agriculture, Washington, D.C.

MALTBY, E. and P.J. DUGAN. 1994. Wetland ecosystem protection, management, and restoration: an international perspective. p. 29–46. In: Davis, S.M. and J.C. Ogden (eds.). Everglades: the ecosystem and its restoration. St. Lucie Press, Delray Beach, Florida.

MAZZOTTI, F.J., T.D. CENTER, F.A. DRAY, and D. THAYER. 1997. Ecological consequences of invasion by Melaleuca quinquenervia in south Florida wetlands:

paradise damaged, not lost. University of Florida, Cooperative Extension Service Publication SS-WEC-123, University of Florida Press, Gainesville, Florida.

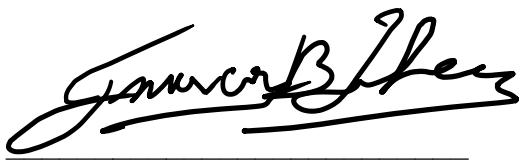
MESKIMEN, G.F. 1962. A silvical study of the Melaleuca tree in South Florida. M.S. thesis, University of Florida, Gainesville, Florida.

MORTON, J.F. 1966. The cajeput tree—a boon and an affliction. Econ. Bot. 20:31–49.

MYERS, R.L. and J.J. EWEL (eds.). 1990. Ecosystems of Florida. University of Central Florida Press, Orlando, Florida.

O'HARE, N.K. and G.H. DALRYMPLE. 1997. Wildlife in southern Everglades wetlands invaded by melaleuca (Melaleuca quinquenervia). Bull. Florida Mus. Nat. Hist. 41:1–68.

WOODALL, S. L. 1981. Integrated methods of Melaleuca control. Pp. 135-140 in: Geiger, R.K. (ed.), Proceedings of Melaleuca Symposium, September 23-24, 1980. Florida Department of Agric. and Consumer Services, Division of Forestry. 140 pp. Tallahassee.



François B. Laroche