Appendix 14: Vegetation Management Within the Everglades Protection Area

François B. Laroche and Gordon E. Baker, South Florida Water Management District

The South Florida Water Management District's Vegetation Management Program is responsible for nuisance exotic vegetation management in 16 counties in central and southern Florida, an area of 15,673 square miles. The District manages exotic plants in more than 1,800 miles of canals and levees, 100,000 surface acres of public lakes, over 850,000 acres of Everglades Water Conservation Areas and other public lands.

The goal of the Vegetation Management Program is the “maintenance control” of nuisance vegetation throughout the District through an Integrated Pest Management (IPM) strategy. Florida Statute, Chapter 369.22 defines a “maintenance program” as “a method of managing exotic aquatic plants in which control techniques are utilized in a coordinated manner on a continuous basis in order to maintain plant populations at the lowest feasible level.” Maintenance control results in the use of less herbicide, the deposition of less organic matter (from dead leaves and other plant parts) on the bottom of the waterbody, less overall environmental impact by weeds, and reduced management costs.

The District has been actively engaged in controlling nuisance vegetation in the Everglades Protection Area (EPA) since the canal and levees were constructed in the early 1950s. Primary efforts at controlling floating and submersed vegetation have been and continue to be with the use of Environmental Protection Agency and Department of Agriculture and Consumer Services approved herbicides. Ditchbank and rights of way vegetation problems are treated with both herbicides and mechanical means, such as mowing and chopping.

In 1972, the Florida Conservation Foundation monthly newsletter published several paragraphs reporting the invasion of three exotic trees in Florida, melaleuca, Australian pine and Brazilian pepper. In 1975, two public interagency workshops, sponsored by Florida Game and Fresh Water Fish Commission, were held to determine ways to control melaleuca in South Florida. Continuation of these workshops led to the formation of the Exotic Pest Plant Council in 1984, and the Melaleuca Task force in 1990. Subsequently the District initiated a major melaleuca control program in the

Everglades Conservation Areas. Melalueca continues to be primary target of the District's exotic plant control operation within the EPA.

MELALEUCA

District efforts to control melaleuca, along with those of other governmental agencies and private groups are containing its spread within the Everglades Water Conservation Areas (WCAs) and the marsh of Lake Okeechobee. Melaleuca has been completely cleared from Water Conservation Area 2A, 3B, and 3A, north and south of Alligator Alley. These areas are now under "maintenance control". Today, the melaleuca infestation is no longer increasing, in many areas it is being reduced.

Funding - The District's melaleuca control funding is derived from several sources (**Table A14-1**). In the past eight years $16,722,794 has been budgeted by the District to fight melaleuca infestations. Approximately $9,712,794 (58%) of this amount has come from sources other than District resources. These include, the Florida Power and Light mitigation Funds (FP&L), the Surface Water Improvement and Management fund (SWIM), the USACE and a FDEP cost sharing program, with District ad valorem taxes providing the balance. SWIM and USACE funds are available for work in Lake Okeechobee only. Several of the current funding sources may be unable to continue supporting the project in future years. SWIM funding was lost in 1996 and the FP&L support ceased in 1994. Fortunately the FDEP and the USACE and the District are continuing to fund the project. Continued availability of funds is essential for the continued success of the melaleuca management program. At the current level of funding, melaleuca could be eliminated from the Everglades Water Conservation Areas and the marshes of Lake Okeechobee within the next ten years.

Table A14-1. South Florida Water Management District's melaleuca management funding sources.

FY	FP&L	DEP	SOR	SWIM	COE	DISTRICT	TOTAL
91	$500,000	--	--	$300,000	--	$170,000	$970,000
92	$500,000	--	--	--	--	$250,000	$750,000
93	$500,000	--	--	$200,000	--	$800,000	$1,500,000
94	--	$400,000	--	$200,000	--	$885,000	$1,485,000
95	--	$1,000,000	--	$400,000	--	$885,000	$2,285,000
96	--	$1,000,000	--	$400,000	$68,000	$885,000	$2,353,000
97	--	$1,000,000	--	--	$300,000	$1,045,000	$2,345,000
98	--	$1,000,000	$300,000	--	$244,794	$1,045,000	$2,589,794
99	--	$1,000,000	$400,000	--	--	$1,045,000	$2,445,000
Total	**$1,500,000**	**$5,400,000**	**$700,000**	**$1,500,000**	**$612,794**	**$7,010,000**	**$16,722,794**

The District continues to support, at $150,000 per year, the U.S. Department of Agriculture research for biocontrol of melaleuca. The District is also providing $60,000 to the Everglades National Park and $75,000 to the Loxahatchee Wildlife Refuge, each year, for their melaleuca control programs (**Table A14-2**).

Table A14-2. South Florida Water Management District melaleuca management expenditures.

FY	WCAs	L. O.[1]	PENNSUCO	BIOCONTROL	SUPPORT[2]	TOTAL
91	$614,437	--	--	$75,000	$15,000	$704,437
92	$823,552	--	--	$75,000	$75,000	$973,552
93	$904,923	$211,159	--	$165,000	$75,000	$1,356,082
94	$634,337	$538,841	--	$150,000	$135,000	$1,458,178
95	$1,025,109	$573,859	--	$195,000	$135,000	$1,928,968
96	$1,460,098	$1,064,216	--	$150,000	$135,000	$2,809,314
97	$970,243	$1,042,037	--	$150,000	$135,000	$2,327,643
98	$449,698	$1,074,813	$301,398	$150,000	$135,000	$2,450,888
99	$640,886	$1,166,497	$384,524	$150,000	$135,000	$2,476,907
Total	**$7,523,283**	**$5,671,422**	**$685,922**	**$1,260,000**	**$975,000**	**$16,112,627**

1- Lake Okeechobee

2- Support to Loxahatchee Wildlife Refuge and Everglades National Park

Management Strategy - The integrated management of melaleuca requires a combination of control techniques to be effective. However, biological control methods are not completely available for melaleuca. The melaleuca snout beetle (*Oxyops vitiosa*) was released in WCA-3B near Holiday Park in Ft. Lauderdale, FL in April 1997. This insect is currently spreading and is successfully establishing itself within melaleuca populations in South Florida. Two more Australian insects will be released in the near future.

The District's efforts in developing melaleuca control methods have been concentrated around herbicidal control and the limited use of mechanical and physical control methodologies. The District first implemented melaleuca control strategies, developed by the MTF, in the southeast corner of WCA-3B in November 1990 (Laroche, 1994). The strategy for managing melaleuca is modified, as control methodologies are developed, to improve efficacy and cost effectiveness. The frill and girdle method, in which the bark around the circumference of each tree is completely removed to expose the cambium for application of the herbicide solution, is the primary tool used in the least infested areas. Aerial application is the most economical method for large melaleuca monocultures. The District has been actively involved in the investigation of control methods for mature and seedling trees. Research needs to continue to improve control methods at reduced costs.

Effective melaleuca management requires knowledge of its biology. The reproductive potential of melaleuca is tremendous. 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, frost, physical damage, and herbicide application (Meskimen, 1962). Once released, 15 to 20 percent of the seeds will germinate. These new trees take approximately two years to mature and produce viable seeds (Woodall, 1981a). Follow-up treatment within the second year after the initial treatment is essential to eliminate new seedlings before they can produce viable seeds. Under ideal conditions, melaleuca can be eliminated from an area within two years. The first phase of control targets all existing trees and seedlings in a given area. Using navigational equipment, crews return to the same site to remove any seedlings resulting from the control activities of the previous year. The District's control operations 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 reinfestation levels as low as possible.

The goal of the current melaleuca management program is to contain melaleuca on all District land and to maintain infestation levels as low as possible while minimizing impacts to non target vegetation. The melaleuca management strategy is based on the quarantine strategy described by Woodall (1981a). The least infested areas (outliers) are addressed first, in order to stop the progression of the existing population. Frill and girdle application of a herbicide solution (25% Arsenal®, 25% Rodeo® and 50% water) is the primary method used to kill mature trees. However, the Cut/Stump application of herbicide is also very effective, but remaining stumps may create a navigation hazard for airboat traffic when the marsh is wet. This type of application is used only on trees with base stem diameter of less then three inches. Melaleuca seedlings in mixed communities are usually hand-pulled in an effort to minimize the impact of herbicides on non-target vegetation. Seedlings are left hanging on remaining vegetation or put in a pile to reduce the potential for regrowth.

Until recently, aerial applications of tebuthiuron, hexazinone, triclopyr, imazapyr, and combinations of imazapyr and glyphosate have been used on an experimental basis only. This type of application is becoming essential as control operations are closing in on large areas of melaleuca monocultures. Acceptable results have been obtained, using 3 quarts of Rodeo® and 3 quarts of Arsenal® with 4 quarts methylated seed-oil surfactant in 20 gallons total volume, in large-scale application.

Regardless of the control method used, 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 in the District's program includes: 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. The data are used to produce maps (**Figures A14-1** through **A14-4)** of treatment progress and to keep track of individual melaleuca control sites.

Water Conservation Areas. Melaleuca occurred throughout all the WCAs, with degrees of infestation ranging from ten to greater than twelve thousand trees per hectares. The trees in WCA-2A were widely scattered compared to light to moderate infestation in WCA-3A and 3B. The infestation level in WCA-2B is severe, with nearly 30% of the area containing melaleuca. Much of this area is solid forest and individual tree treatment is not cost effective. Depending on accessibility and remoteness of control sites, a helicopter, airboats, and/or all terrain vehicles are used to transport crews and supplies. Once on site, crews perform melaleuca treatments with the use of the girdle or cut-stump method of herbicide application. Each crew may consist of three to eight people, depending on the density of the melaleuca infestation at the site being treated.

The melaleuca control project began at the southeast corner of WCA-3B in November of 1990 and proceeded northward through WCA-3B, 3A, north and south of Alligator Alley and 2A. These areas are currently under Phase III operations. From November 1990 to October 1999 approximately 10,525,049 trees and 24,920,469 seedlings have been controlled within the WCAs at a total cost of $7,018,151 (**Table A14-3, Figures A14-1** and **A14-2**). Phase I work will continue in WCA-2B during FY 00. Aerial applications in the WCAs are being performed on a limited basis for the control of large melaleuca monocultures. To date, a total of 714 hectares have been successfully treated by aerial application at a cost of $499,899 (**Table A14-4**). Aerial application will continue in WCA-2B to control large monocultures. Crews are also treating light infestation of Brazilian pepper, Australian pine, Java plum along all the canal banks and levees within the WCAs.

Table A14-3. Melaleuca control summary for ground based application in the Water Conservation Areas.

FY	TREES	SEEDLINGS	LABOR[1]	COST/PLANT[2]	TOTAL COST
91	156,001	1,103,073	3,970 h	$0.48	$614,437
92	388,324	547,448	8,775 h	$0.88	$823,552
93	1,391,095	12,142,900	26,241 h	$0.07	$899,690
94	1,571,535	5,439,843	24,000 h	$0.09	$634,337
95	1,336,394	1,603,997	29,045 h	$0.33	$964,734
96	1,551,969	1,877,654	47,241 h	$0.39	$1,267,394
97	1,671,106	884,093	33,709 h	$0.30	$760,689
98	976,132	267,264	22,243 h	$0.36	$449,698
99	1,482,493	1,054,197	22,588 h	$0.29	$603,620
Total	**10,525,049**	**24,920,469**	**217,812 h**	**$0.20**	**$7,018,151**

1- abor hours

2- cost per mature trees - cost per trees and seedlings

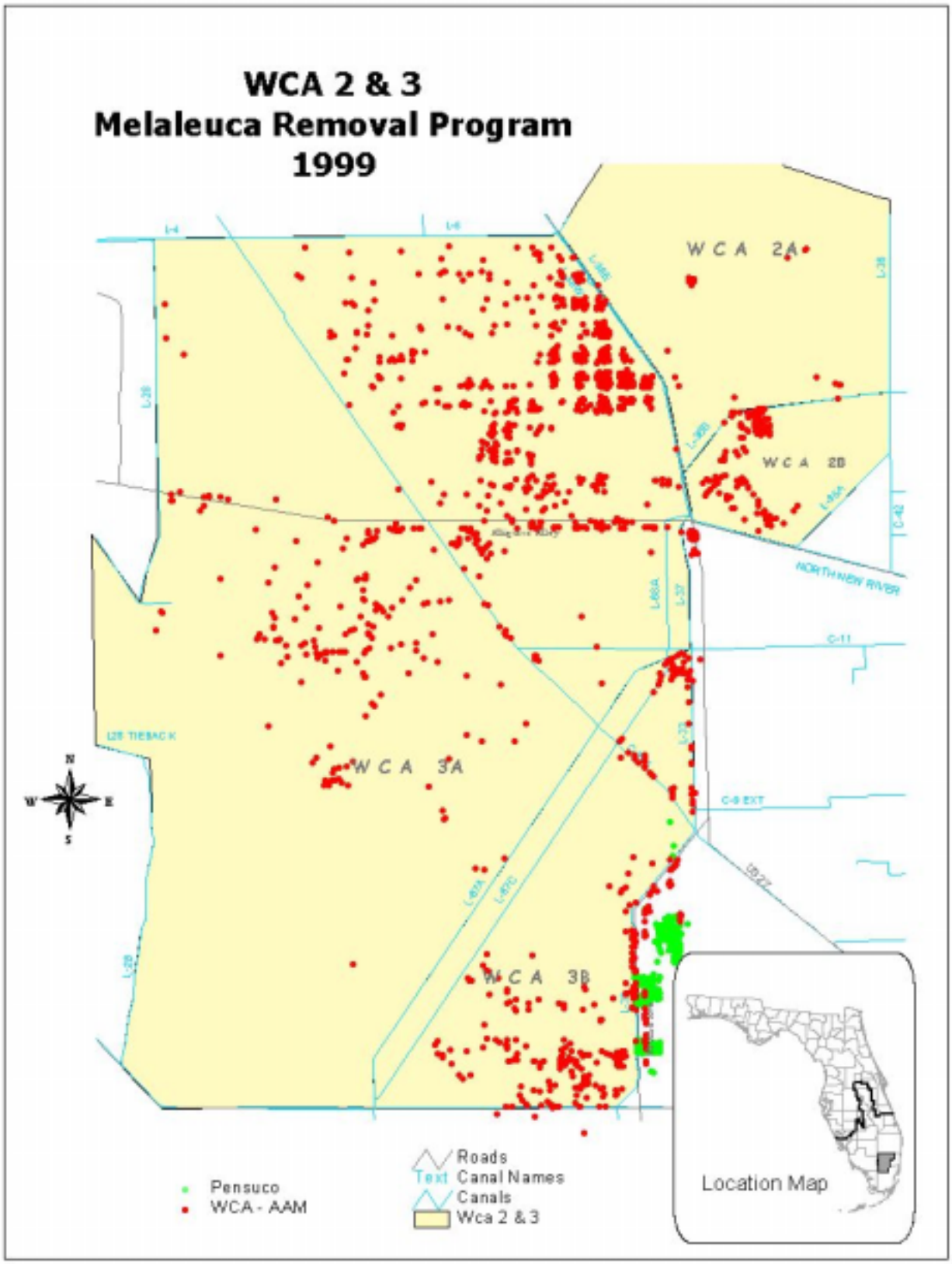


Figure A14-1. Melaleuca infestation and control efforts from 1991-1998 in the Water Conservation Areas and Pennsuco.

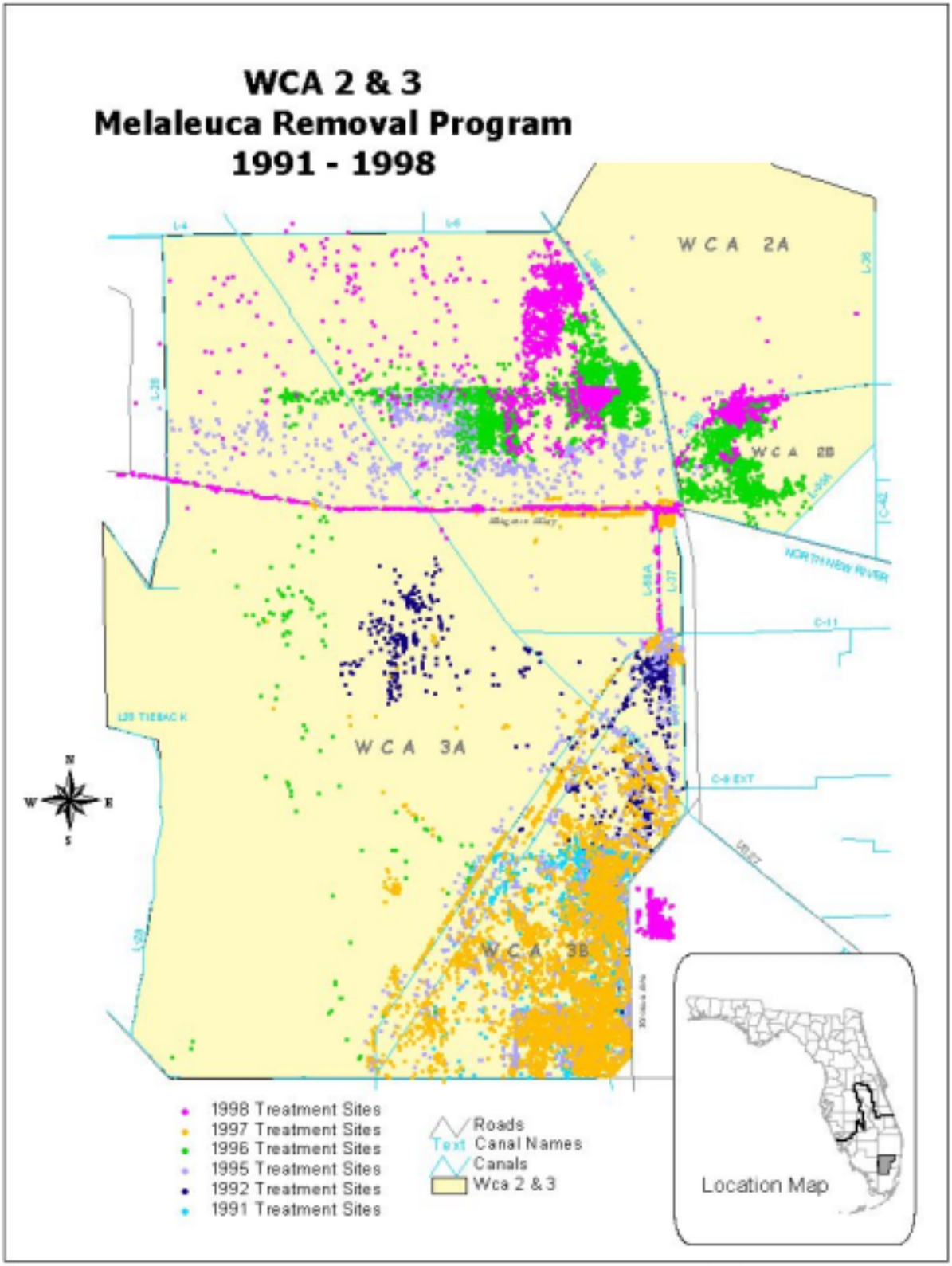


Figure A14-2. Melaleuca infestation and control efforts during FY 1999 in the Water Conservation Areas and Pennsuco.

Table A14-4. Melaleuca Control Summary for Aerial Application in the Water Conservation Areas and Lake Okeechobee From 1994 to 1998.

Water Conservation Areas

Year	Hectares treated	Cost/hectares $	Total cost $
July 1995	101	$601.34	60,375
June 1996	240	$679.39	163,054
November 1996	41	$723.17	29,650
February 1997	283	$740.47	209,554
January 1999	49	$760.53	37,266
Total	**714**		**499,899**

Lake Okeechobee

Year	Hectares	Cost/hectare	Total cost
May 1994	526	$285.32	$150,000
July 1995	81	$596.29	$48,300
June 1996	165	$677.15	$111,731
February, 1997	121	$742.21	$89,808
December 1997	41	$777.09	$31,473
March 1998	607	$761.31	$462,114
January 1999	761	$760.53	$578,763
Total	**2,304**		**$1,472,189**

Pennsuco Wetland

Year	Hectares	Cost/hectare	Total cost
February 1999	61	$758.68	$46,052
Total	**61**		**$46,052**

Lake Okeechobee. The U.S. Army Corps of Engineers originally introduced melaleuca to Lake Okeechobee in the late 1930s (Bodle et al., 1994). These trees were planted on low-lying islands immediately lakeward of the levee to protect the levee system from storm generated wind and wave erosion. From these limited plantings, melaleuca spread into many thousands of hectares of marsh within the lake. There were two main areas of

melaleuca infestation in Lake Okeechobee. The first area includes the levee and marsh zone near the original planting sites. These sites are characterized by large, mature, extremely dense monocultures. The second includes the shallow marsh region of the lake where trees have spread lakeward. Melaleuca infestations in the outer marsh typically consisted of outliers and small groups of trees (heads) of varying ages. The lake has been divided into seven management sections, each with varying degrees of infestation.

Melaleuca control operations on Lake Okeechobee began in August 1993. The goal of the melaleuca management program on Lake Okeechobee is to first contain, then progressively reduce populations within the littoral zone. To date, significant headway has been made on the outlier trees and heads in the outer marsh of sections 1, 2, 3, 4 and 6 (**Figures A14-3** and **A14-4**). From July 1993 to October 1999, a total of 12,484,802 trees and 9,491,503 seedlings have been eliminated in the lake at a total cost of $4,199,2351 (**Table A14-5**). The U.S. Army Corps of Engineers has removed melaleuca, Australian pine and Brazilian pepper from the land-ward side of the rim canal in section. The USACE is also providing funds to the District to eliminate melaleuca trees along the lake-ward side of the rim canal in sections 1, 2 and 3. During FY 99 Phase II was completed in sections 1, 2, 3 and 4. Section 6 is currently in Phase III. Phase I work will continue in section 5 during FY00. A total of 761 hectares of melaleuca monoculture were treated by aerial application, in the Lake, at a cost of $578,763. As in the WCAs, this program is primarily ground-based herbicide application, although the development and implementation of a safe and effective aerial application for melaleuca control is critical to this project. A total of 2,304 hectares of mature melaleuca monoculture have been successfully treated by aerial application on Lake Okeechobee (**Table A14-4).**

Table A14-5. Melaleuca control summary for ground based application in Lake Okeechobee.

FY	TREES	SEEDLINGS	LABOR[1]	COST/PLANT[2]	TOTAL COST
93	523,461	1,134,468	9,292 h	$0.07	$211,159
94	1,751,510	4,473,004	22,011 h	$0.06	$388,841
95	2,871,825	1,537,966	24,742 h	$0.12	$525,559
96	3,214,546	1,288,292	43,726 h	$0.21	$952,485
97	2,141,026	562,569	43,724 h	$0.34	$920,756
98	1,663,744	181,910	28,312 h	$0.33	$612,700
99	318,690	313,294	28,273 h	$0.93	$587,735
Total	**12,484,802**	**9,491,503**	**190,788 h**	**$0.20**	**$4,199,235**

1- abor hours

2- cost per mature trees - cost per trees and seedlings

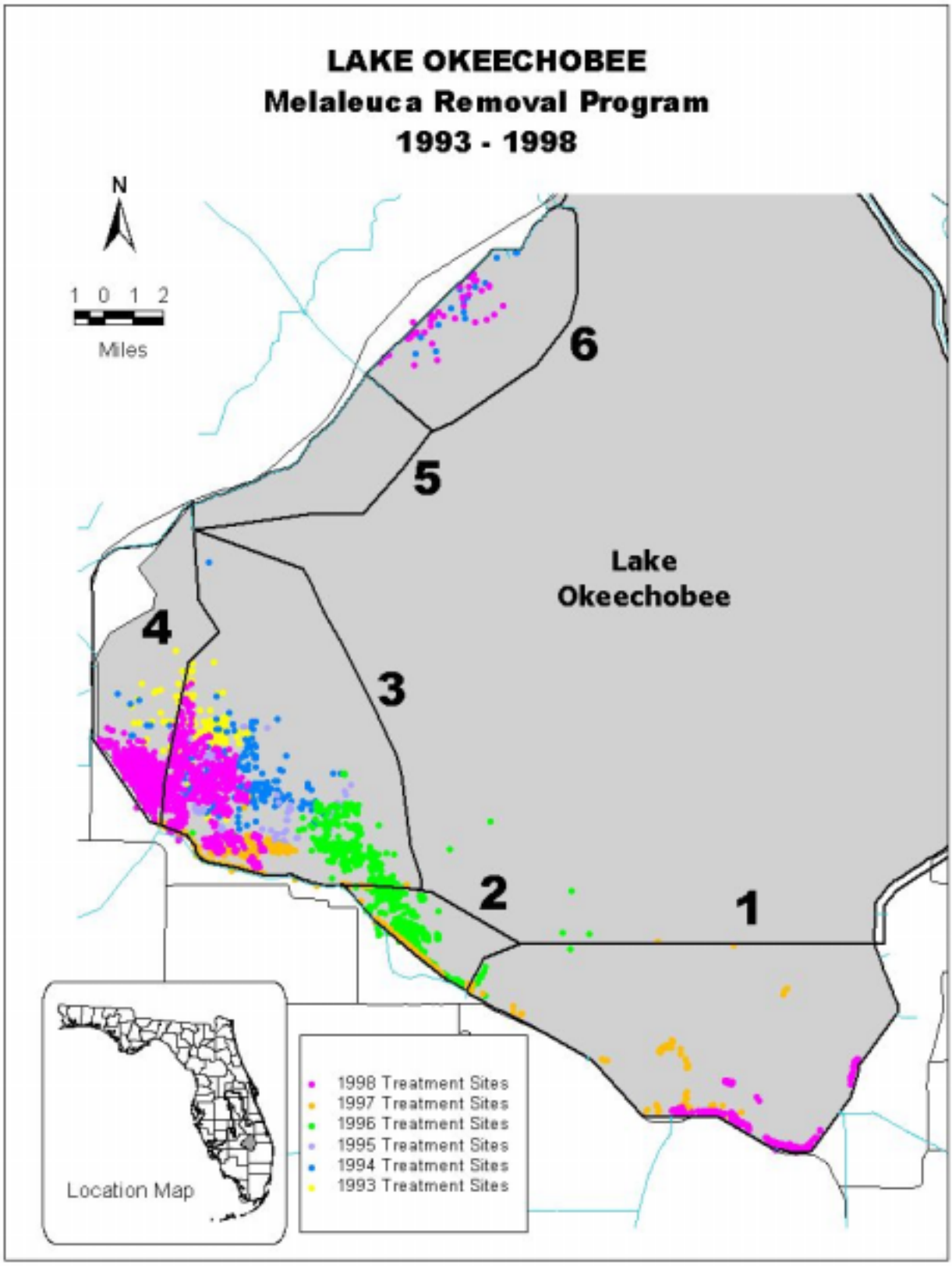


Figure A14-3. Melaleuca infestation and control efforts from 1993-1998 in management sections of Lake Okeechobee.

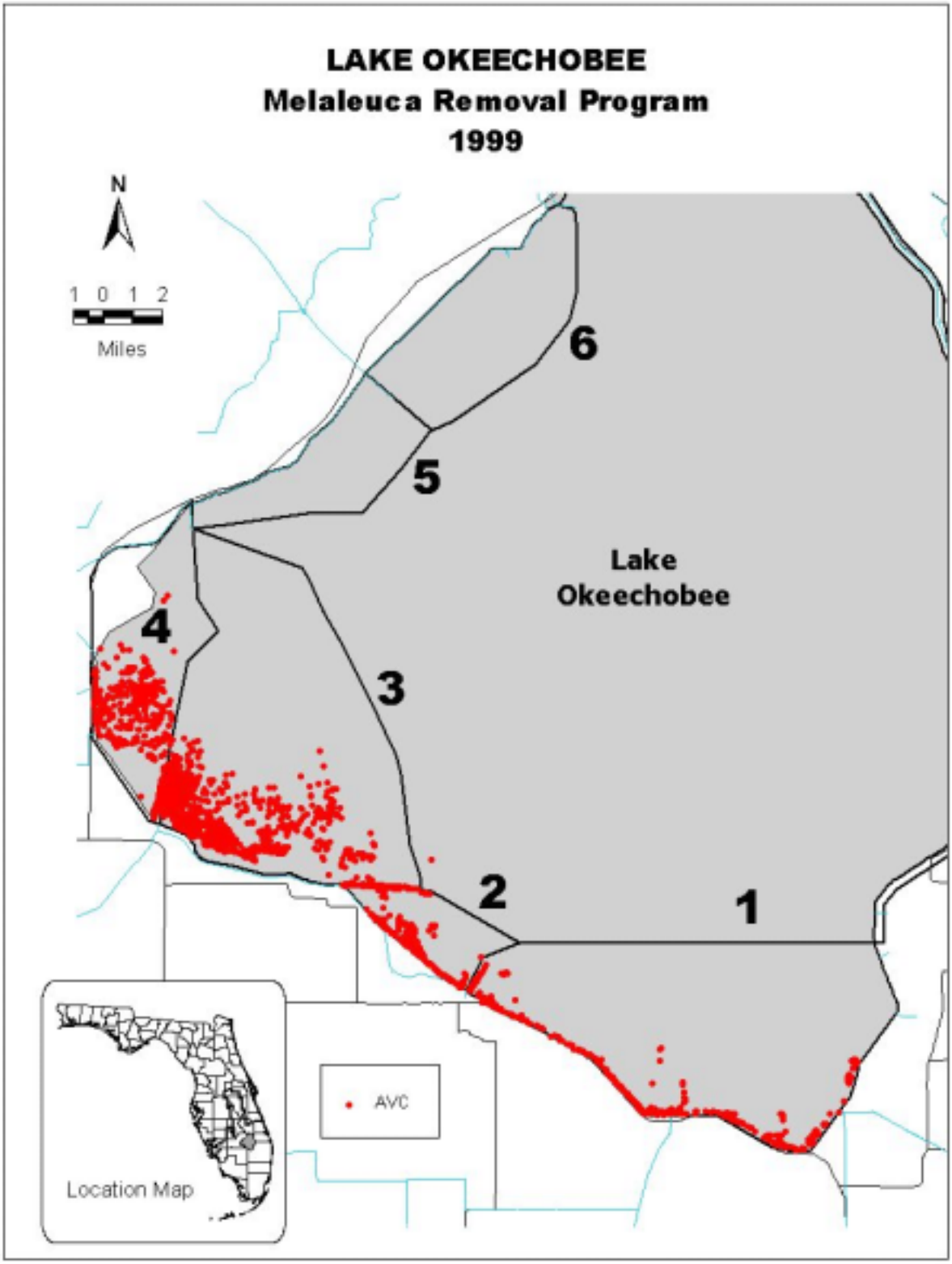


Figure A14-4. Melaleuca infestation and control efforts during FY 1999 in management sections of Lake Okeechobee.

Pennsuco Mitigation area. Mitigation funds are used to acquire and enhance lands within the Pennsuco project located in Dade County, Fl. The benefits of utilizing this project area for mitigation include eradication of exotic vegetation to ensure the enhancement, preservation and maintenance of the wetland systems.

The eradication of melaleuca is the only wetland enhancement activity that is planned for this area. The purpose of the exotic eradication effort is to effectively manage melaleuca by containing and progressively reducing melaleuca populations within the Pennsuco Project. The control program consists primarily of a ground based herbicide application and some use of aerial application in the dense monocultures.

A total of 1,1460 hectares of melaleuca have been treated by ground application. The exotic treatment consisted of hand pulling seedlings and girdle treatment for isolated individuals and smaller infestations. Approximately 6,946,306 trees and 3,765,784 seedlings were treated at a cost of $639,869 (**Table A14-6**). A total of 61 hectaares of dense melaleuca monoculture were treated by aerial application during the first week of February 1999.

Melaleuca control in the Pennsuco wetlands will continue as the District continues to buy more land within the Pennsuco mitigation area. The use of prescribed burning will facilitate seedling control and hopefully reduce the need for phase II control and help maintain a mosaic of vegetation types within the enhanced sawgrass community

Table A14-6. Melaleuca control summary for ground based application in the Pennsuco mitigation area.

FY	TREES	SEEDLINGS	LABOR[1]	COST/PLANT[2]	TOTAL COST
98	3,412,548	1,757,502	13,175 h	$0.06	$301,398
99	3,533,758	2,008,282	14,485 h	$0.06	$338,471
Total	**6,946,306**	**3,765,784**	**27,660 h**	**$0.06**	**$639,869**

1-labor hours

2- cost per mature trees - cost per trees and seedlings

Conclusion - The operational and experimental work accomplished to date, demonstrates that melaleuca can be effectively and consistently controlled using an integrated management approach. The ultimate control of melaleuca throughout the District will depend primarily on the future availability of funds. The magnitude of the threat of melaleuca and the cost of current control efforts are enormous. However, at the current rate of treatment, melaleuca should be under maintenance control in the Water Conservation Areas and in Lake Okeechobee within the next 10 years.

The elimination of melaleuca from the Everglades, Lake Okeechobee and other District's managed lands may cause a temporary disruption of the native flora. However, any sign of disturbance caused by control treatments usually vanish within one to two years. This temporary adversity is an acceptable event in ridding these natural areas of an invasive exotic pest plant. Only through Melaleuca eradication can we insure the sustainability of these treasured wildlands.

AQUATIC AND RIGHTS OF WAY EXOTIC NUISANCE VEGETATION MANAGEMENT

The success of a vegetation management program is dependent on meeting established performance objectives. The District's vegetation management objectives are:

For Lakes:
- Maintain 99.9% of the waterbody unobstructed by targeted floating plants.
- Maintain submersed and emersed plants in the waterbody in accordance with interagency objectives (i.e., fisheries, water flow, navigation, and habitat stabilization).

For Canals:
- Maintain 99% of canal unobstructed by targeted floating plants and 100% clear around water control structures.
- Maintain more than 50% of water column unobstructed by targeted submersed vegetation in accordance with prioritized workplans.
- Maintain targeted emergent plants 90% clear of waterbody only when impairment of intended use occurs.

For Ditchbank and rights of way:
- Maintain targeted ditchbank vegetation in accordance with prioritized workplans.
- Eliminate exotic woody species on District levees and rights-of-way according to prioritized workplans.

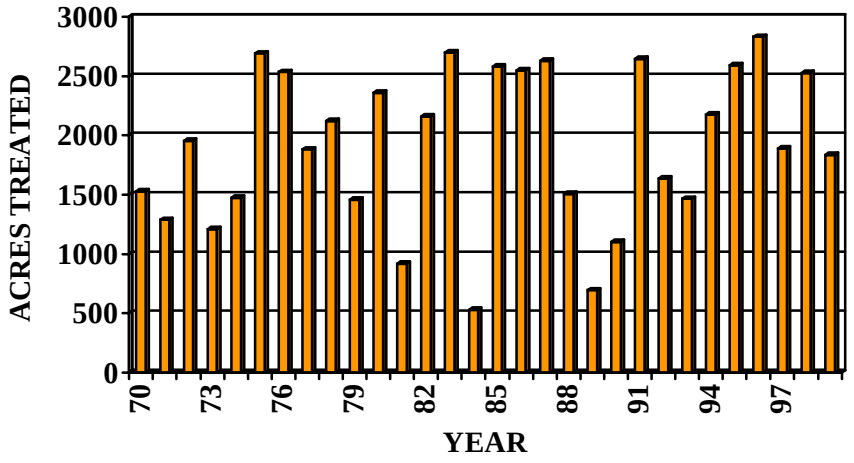
It is anticipated that by implementing these objectives, the waterbodies and-rights-of way in the District will be maintained in a balanced condition maintaining exotic vegetation types at the lowest possible level while encouraging native communities to thrive and still allow for the proper movement of water for flood protection and water supply. The sub-tropical climate along with an almost year-round growing season is one of the main factors in creating the lush vegetative communities populating the water resources of the area. Other factors include naturally eutrophic waters, lake stabilization, increased run-off of nutrients from a myriad of human related activities, and the constant introduction of exotic species into the area. Aquatic plant management in the District: (1) keeps navigation channels open, (2) provides drainage and flood water abatement, (3) keeps water control structures and pumping facilities unobstructed, (4) enhances fish and wildlife habitats, (5) reduces mosquito breeding areas, (6) reduces destruction of native plant communities, and (7) enhances aquatic recreational activities.

The problem species treated by District personnel are grouped into four major categories: floating, submersed, emersed, and ditchbank plants.

Floating plants - are not rooted in the soil, they are free-floating and easily moved around by wind and water currents. The primary target species are waterhyacinth and waterlettuce. Control of floating vegetation is primarily through the application of herbicides. Waterhyacinth is easily controlled with 2, 4-D at the rate of 1 to 2 quarts per acre. Waterlettuce requires the use of Reward at the rate of 1 to 2 quarts per acre. These herbicides are applied in 100 to 150 gallons of water per acre from airboats or jonboats. Large infestations in remote locations are sometimes treated with aerial applications of the materials in 10 gallons per acre of water. Occasionally, these plants will accumulate at various structures and require physical removal using mechanical methods.

Emersed plants - are rooted in the bottom with leaves extending above the surface of the water. These weeds include spatterdock, cattails, water pennywort, and several others. The method of control for emersed weeds is the same as for floating weeds except that Rodeo® and the combination of Rodeo® plus 2, 4-D is used. Rodeo is applied at the rate of 6–7 ½ pints per acre in 100 to 150 gallons of water. For water pennywort and others, 2, 4-D may be added to the mix at 1 to 2 quarts per acre. A total of 2,500 acres of emersed and floating plants were treated within the EPA during FY98 (**Table A14-7**).

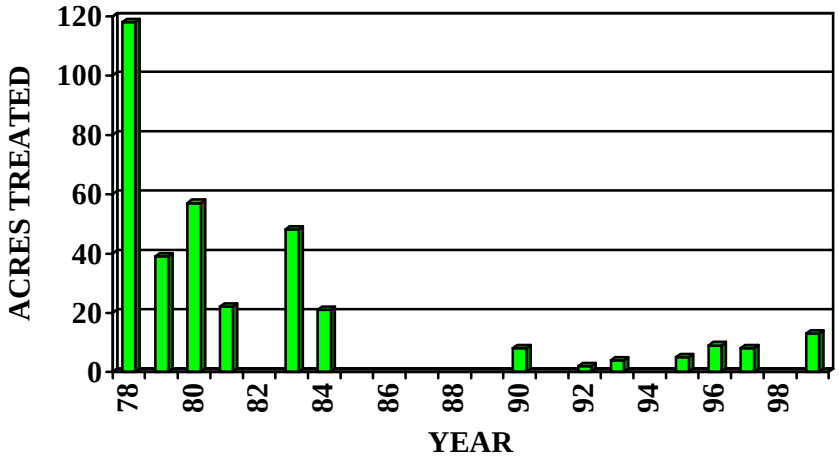
Table A14-7. Acres of floating and emersed vegetation treated by District crews in the Everglades Protection Area from 1970 to 1999.



Submersed plants - are rooted in the soil of the waterbody and grow toward the surface of the water, sometimes extending a short distance out of the water. The primary target species in this category include hydrilla, hygrophila, and Illinois pondweed. Control of submersed vegetation in this area has been done very rarely in comparison to the treatment of floating, emersed, and ditchbank weeds (**Table A14-8**). The presence of

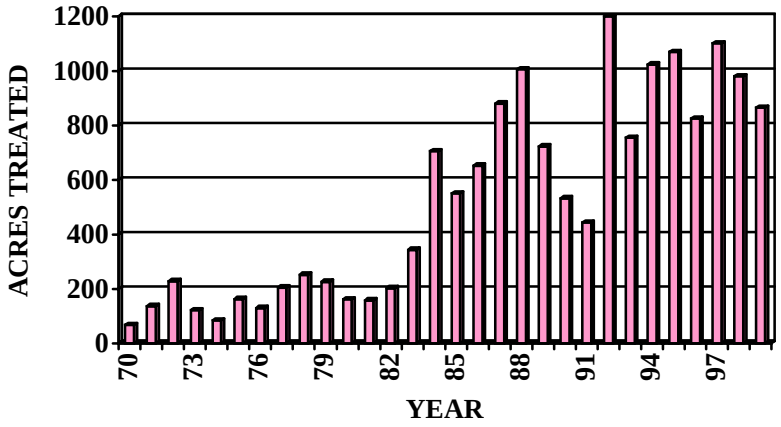
submersed vegetation in the Everglades Protection Area has not caused as many negative effects as floating and emersed plants.

Table A14-8. Acres of submersed vegetation treated by District crews in the Everglades Protection Area from 1970 to 1999.



Ditchbank plants - generally are terrestrial in nature although some species extend their rhizomes onto the surface of the waterbody. These plants include torpedograss, paragrass, Phragmites, Napiergrass, and all the woody exotics such as Melaleuca, Australian pine, Brazilian pepper, and Java plum. Control of the grasses can be effected by spraying Rodeo® (7 ½ pints per acre) or Arsenal® (2 to 3 quarts per acre) from either a boat or truck application system. Woody species are controlled using hack-and-squirt or basal bark treatments, depending on species. Brazilian pepper and Australian pine are treated using the basal bark application method of a 20 to 25% solution of Garlon 4® in a carrier oil. The same herbicide is used for Java plum and earleaf accacia but the girdle method is used. When ditchbanks and rights-of-ways are densely infested, aerial application can be used to facilitate maintenance operations.

Table A14-9. Acres of ditchbank vegetation treated by District crews in the Everglades Protection Area from 1970 to 1999.



Conclusion - The aquatic and rights-of-way vegetation management program is an ongoing effort requiring continued expenditure of funds for maintaining the land and water resources of the EPA. District crews conduct the majority of the aquatic and rights-of-way vegetation management within the EPA. However, both ground and aerial contracts are sometimes used to supplement these efforts.