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Wetlands Research Program Technical Report WRP-SM-15

Evaluation of Mechanical and Chemical Methods for Control of *Melaleuca quinquenervia* in Southern Florida

by Alfred F. Cofrancesco, Jr., Jean W. Wooten, Harvey L. Jones

December 1995 – Final Report
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	Task		Task
CP	Critical Processes	RE	Restoration & Establishment
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Wetlands Research Program

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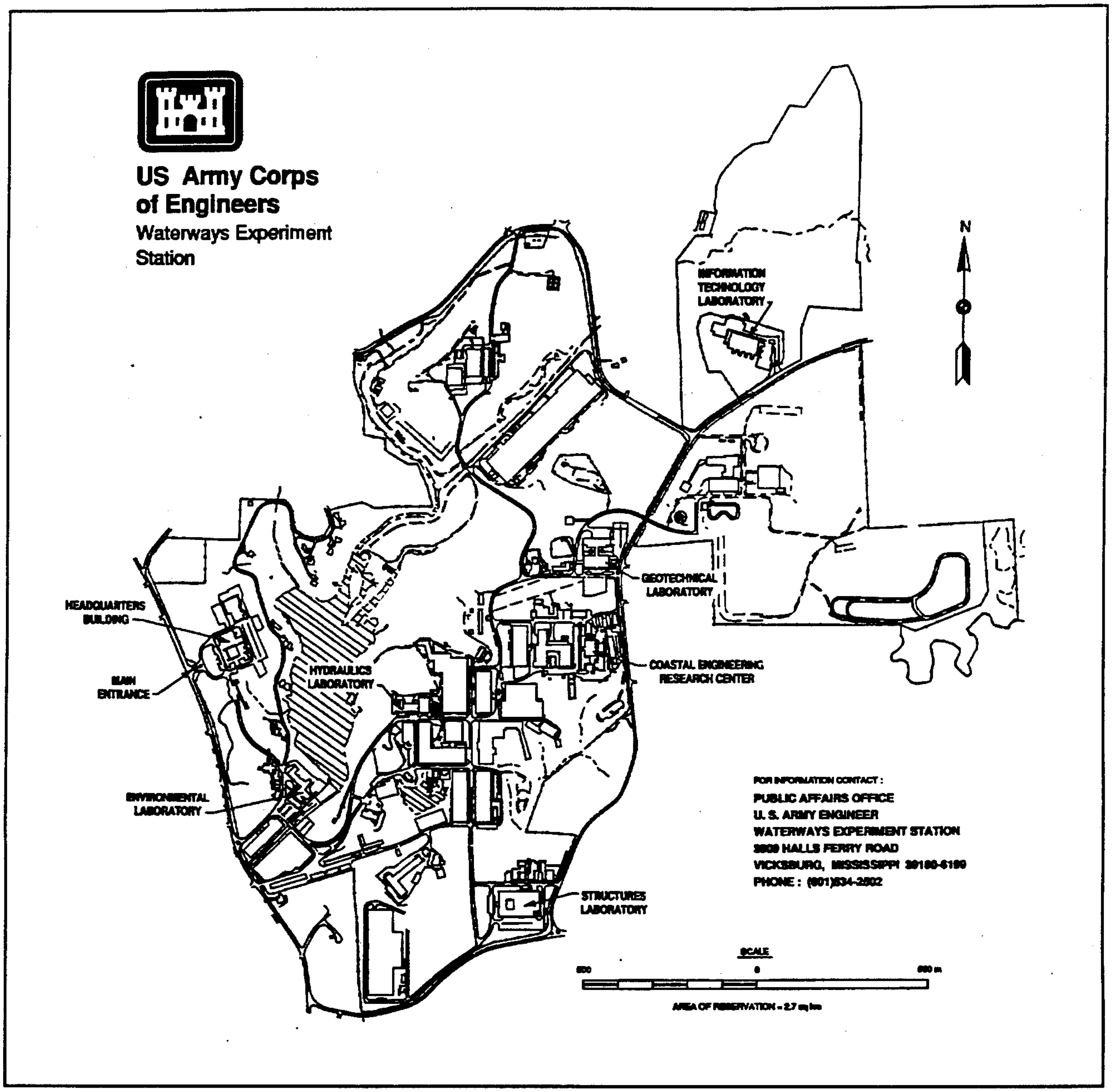

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Wetland Pests

Evaluation of Mechanical and Chemical Methods for Control of Melaleuca quinquenervia in Southern Florida (TR WRP-SM-15)

ISSUE:

Melaleuca quinquenervia (Cav.) Blake, common names melaleuca, cajeput, or punk tree, is native to the Australian region. Trees were first planted in southern Florida early in the 20th century. Starting in the late 1940s, melaleuca was planted by U.S. Army Engineer personnel at Lake Okeechobee, Florida, to serve as wind barriers and to provide protection for the levees surrounding the lake. The trees have now spread to wetland habitats and were found by a 1979 survey to grow along 88.5 km (53.1 miles) of the 175 km (105 miles) of levee road and to cover approximately 96.8 ha (242 acres) in these perimeter stands (Stocker 1982a). Additionally, Stocker found that "in the lake proper, melaleuca is found in approximately 420 ha (1,050 acres), where it offers as isolated individuals and as dense colonies (heads) up to 0.6 ha (1.5 acres) in size." This distribution of trees was approximately 0.3 percent of the lake acreage.

RESEARCH:

The objectives of this study were to determine the effects of selected treatment methods on vegetation regrowth and to assess their results in control of melaleuca. Seven approximately 3.3-ha plots were established in 1990 near Moore Haven, FL, along the southwest Lake Okeechobee levee road. Trees within the plots were mechanically uprooted and piled in the center of the plots. One year later they were burned and the areas harrowed with a disk. Treatments for each plot and numbers of transects and quadrats used in this work are listed in Table 1. After 1 and 2 years, the results of these treatments were assessed.

SUMMARY:

For comparison with melaleuca regeneration in the test plots, trees, as numbers and as stem counts, were determined for an undisturbed site near the test plots. In preparation for harvesting and herbicide treatment, two stands (heads) within Lake Okeechobee were measured and stems counted. To assess melaleuca regeneration after mechanical uprooting of trees and no further site treatment, an area cleared in 1992 was surveyed.

AVAILABILITY OF REPORT:

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About the Authors:

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Preface

The work described in this report was authorized by Headquarters, U.S. Army Corps of Engineers (HQUSACE), as part of the Stewardship and Management Task Area of the Wetlands Research Program (WRP). The work was performed under Work Unit 32766, Wetlands Stewardship and Management Demonstration Areas, for which Mr. Chester O. Martin, U.S. Army Engineer Waterways Experiment Station (WES), was the Technical Manager. Ms. Denise White, (CECW-ON) was the WRP Technical Monitor for this work.

Mr. Dave Mathis (CERD-C) was the WRP Coordinator at the Directorate of Research and Development, HQUSACE; Dr. William L. Klesch (CECW-PO) served as the WRP Technical Monitor's Representative; and Dr. Russell F. Theriot, WES, was the Wetlands Program Manager. Mr. Martin was the Task Area Manager.

The work was performed at WES by Dr. Alfred F. Cofrancesco, Principal Investigator, Dr. Jean W. Wooten, University of Southern Mississippi, and Mr. Harvey L. Jones, Aquatic Ecology Branch (AEB), Environmental Laboratory (EL), WES, under the supervision of Dr. Edwin A. Theriot, Chief, AEB; Dr. Conrad J. Kirby, Chief, Ecological Research Division, EL; and Dr. John W. Keeley, Director, EL.

We are appreciative for the assistance of Mr. Ron Medima, USACE, Clewiston, for providing us with information on the site. We also thank Ms. Debbie Miller, Ms. Janis Lanier, Mr. Robert Dew, Jr., Mr. Christopher Bunch, and Mr. Bradley Lewis for assistance with laying out transects, sampling vegetation along the transects, and recording data.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Bruce K. Howard, EN.

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Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
inches	2.54	centimeters
miles (U.S. statute)	1.609347	kilometers

1 Introduction

Background

Melaleuca quinquenervia (Cav.) Blake, common names melaleuca, cajeput, or punk tree, is native to the Australian region. Trees were first planted in Southern Florida early in the 20th century. Starting in the late 1940s, melaleuca was planted by U.S. Army Engineer personnel at Lake Okeechobee, Florida, to serve as wind barriers and to provide protection for the levees surrounding the lake. The trees have now spread to wetland habitats and were found by a 1979 survey to grow along 88.5 km (53.1 miles) of the 175 km (105 miles) of levee road and to cover approximately 96.8 ha (242 acres) in these perimeter stands (Stocker 1982a) (Figure 1). Additionally, Stocker found that "in the lake proper, melaleuca is found in approximately 420 ha

Figure 1. Mature stand of *Melaleuca quinquenervia* trees at Lake Okeechobee, Florida

(1,050 ac), where it offers as isolated individuals and as dense colonies (heads) up to 0.6 ha (1.5 ac) in size." This distribution of trees was approximately 0.3 percent of the lake acreage.

It has been estimated that the trees have invaded and occupy 10^6 ha in southern Florida and are spreading to new areas at a rate of about 1,000 ha/year; stands with as many as 5,000 stems per hectare have been reported (DiStefano and Fisher 1983/1984). Attempts to control mature melaleuca at Lake Okeechobee have resulted in reestablishment of dense stands of seedlings (Stocker 1982b). A factor in the aggressive colonizing ability of this species is that trees are often multistemmed and flower up to three times per year. Numerous flowers are borne on the current season's branch growth, the branches continue to grow, and leaves are formed beyond the flowers (Meyers 1983). Approximately 250 very small seeds may be formed in each closed, woody capsule (Woodall 1982). Woodall reported that seed release occurs when the moisture supply to the capsule is interrupted by fire, frost, wind, natural pruning, or human activities. Alexander and Hofstetter (1975) estimated that a single 10-m-tall tree could store over 20 million seeds in its capsules.

Woodall (1983) studied the establishment of melaleuca seedlings in the pine-cypress ecotone of southwest Florida. He found that seeds were long-lived on or in the soil and lost no germination ability after 10 months of shallow burial in a swamp, but seeds buried in a well-drained area lost two-thirds of their viability in this time span. He also reported that burial prevented germination. Moist to saturated soils for several months but rarely flooded provide optimum conditions for tree establishment (Myers 1983).

In order to determine possible mechanisms to control the growth and spread of melaleuca in Lake Okeechobee, the U.S. Army Engineer District, Jacksonville, Florida, sponsored work by Dr. R. K. Stocker of the U.S. Army Engineer Waterways Experiment Station. Five 1982 reports document evaluation of the results of (a) determination of tree distribution at Lake Okeechobee, (b) five herbicides for the control of melaleuca seedlings, (c) four herbicides for the control of mature melaleuca on dredged material islands and levees, (d) five herbicides for control of mature melaleuca by injection, and (e) tree harvesting. These preliminary studies indicated that seedlings and mature trees can be killed by herbicides; injection was about 90-percent effective; and that after 4 months, 66 percent of cut tree stumps resprouted (Stocker 1982a,b,c,d,e).

Objectives

The objectives of this study were to determine the effects of selected treatment methods on vegetation regrowth and to assess their results in control of melaleuca. Seven approximately 3.3-ha plots were established in 1990 near Moore Haven, FL, along the southwest Lake Okeechobee levee road. Trees within the plots were mechanically uprooted and piled in the center of the plots. One year later they were burned and the areas harrowed with a disk. Treatments for each plot and numbers of transects and quadrats used in this work are listed in Table 1. After 1 and 2 years, the results of these treatments were assessed by methods described below. For comparison with melaleuca regeneration in the test plots, trees, as numbers and as stem counts, were determined for an undisturbed site near the test plots. In preparation for harvesting and herbicide treatment, two stands (heads) within Lake Okeechobee were measured and stems counted. To assess melaleuca regeneration after mechanical uprooting of trees and no further site treatment, an area cleared in 1992 was surveyed.

Table 1
Treatment of Melaleuca Test Plots and Numbers of Transects and Quadrats Sampled

Plot	Date	Treatment	No. Transects	No. Quadrats
1		Manual clearing of recurring melaleuca	7	56
2	7/15/91	Planted *Taxodium* and *Acer* saplings	8	69
3	6/17/91	Rodeo herbicide @ 6.96 L/ha; disk twice on 7/10/91; planted Japanese and Brown Top Millet 2/29/92 @ 56 kg/ha	7	55
4	6/17/91	Rodeo herbicide @ 6.96 L/ha	8	64
5	6/17/91	Control; mechanical clearing	8	64
6	6/17/91	Velpar L herbicide @ 18.8 L/ha	8	63
7	6/17/91	Velpar L herbicide @ 9.38 L/ha	8	65

2 Methods

To eliminate edge effects, 12.8 m were measured at each plot side and plastic pipes were set at the four corners. Surveying flags were placed each 30.5 m from the front corner post to a location where less than 30.5 m existed to the next plot. Survey flags were placed every 15.2 m along each transect line.

At each flagged quadrat point, a 1-m^2 plastic quadrat was placed with the survey flag in the center (Figure 2). The names of the plant species present were recorded. Percent cover and growth form were estimated using the scales listed in Table 2. All melaleuca in the study areas in each plot were counted, and estimated height and counted numbers of stems noted.

Figure 2. Sampling quadrat at Lake Okeechobee, Florida

Table 2
Estimate Scales for Percent Cover According to Daubenmire (1959) and Dispersion According to Braun-Blanquet (1965)

Cover			Dispersion	
No.	Percent	Midpoint	No.	Description
1	0-5	2.5	1	Growing solitary
2	5-25	15.0	2	Clumps or dense groups
3	25-50	37.5	3	Small patches or cushions
4	50-75	62.5	4	Small colonies or forming large carpets
5	75-95	85.0	5	Large almost pure population stands
6	95-100	97.5		

The following formulas were used for data analyses from each plot:

1) Percent frequency = $\frac{\text{the number of quadrats in which a species occurred}}{\text{the total number of quadrats sampled}} \times 100$

2) Relative frequency = $\frac{\text{the number of quadrats in which a species occurred}}{\text{the number of quadrats in which all of the species occurred}} \times 100$

3) Percent cover = $\frac{\text{sum of percent cover for the species}}{\text{total } m^2 \text{ sampled in the plot}}$

4) Maximum percent possible cover = $\frac{\text{sum of percent cover}}{\text{(maximum possible percent cover (97.5))} \times \text{no. quadrats sampled in the plot}}$

Each cover scale value was converted to the midpoint percentage of the Daubenmire (1959) class (Table 2).

Similarity between each of the plots was calculated by:

Jaccard's Index of Community Similarity based on presence-absence (Jaccard 1928).

5) $IS_J = \frac{\text{Number of common species}}{\text{No. unique species in Plot A} + \text{No. unique species in Plot B} + \text{No of common species}} \times 100$

Ellenberg's Index of Community Similarity based on species quantities (Ellenberg 1956)

6) $$IS_E = \frac{\text{Sum of percent cover of common species Plot A \& B /2}}{\text{Sum of percent cover of unique Plot A species} + \text{Sum of percent cover of unique Plot B species} + \text{Sum of percent cover of species common to Plot A \& Plot B/2}} \times 100$$

Each plot was divided into three parts: (a) the area in front of the berm toward the levee, (b) the berm, and (c) the area toward the canal to the rear of the berm. In 1992, soil samples were taken from each of these three areas according to the zigzag technique suggested by the Mississippi Soil Testing Service. For each area in each plot, an aggregate sample was accumulated, sun dried, mixed, and an aliquot removed and sent to the Mississippi Soil Testing Service for analyses of pH, organic matter, phosphorus, potassium, calcium, magnesium, zinc, sulfur, and cation exchange capacity. Results of these analyses were subjected to a one-way analysis of variance procedure.

Stem Counts in a Melaleuca Stand

A population of trees between the levee and rim canal approximately 4.8 km (3 miles) north of the test plots was selected as a "typical undisturbed area." The melaleuca stems within a 0.386-ha (0.952 acre) area were counted in 1992. Trees with stems less than 0.1 m (4 in.) in diameter were recorded as saplings.

Stem Counts in Two Melaleuca Stands in Lake Okeechobee

"Head" 1 was off the airboat trail. Two stakes were affixed to trees distant from the south and west sides of the head. Stake 1 at the south was 230 deg from Stake 2. Stake 1 was 40.5 m (133 ft) and 191 deg from Tree 1 at the southeast corner of the head. Stake 2 was 35 m (115 ft) and 95 deg from Tree 1. The head was measured and the melaleuca stems counted in 1992.

"Head" 2 was northeast of Head 1. Two stakes were affixed to trees distant from the south and east sides of the head. Stake 1 was 128 deg from Stake 2. Stake 1 was 46.9 m (154 ft) and 175 deg from Tree 1 at the southeast corner of the stand. Stake 2 was 39.3 m (129 ft) and 245 deg from Tree 1. The head was measured and the melaleuca stems counted in 1992.

Regeneration of Melaleuca After Mechanical Clearing

In July 1992, an approximately 1-mile[1] section between the levee and the rim canal was mechanically cleared of melaleuca. The trees were stacked, and no further work was done in the area. In 1993, the numbers of regenerated trees were quantified by establishing 16 transect lines 6 m apart across an area including the space between two piles of trees. These lines were sampled with a square meter quadrat every 6 m.

1 A table of factors for converting non-SI units of measurement to SI units is presented on page ix.

3 Results and Discussion

A total of 54 transect lines and 436 1-m^2 quadrats were sampled (Table 1). There were 106 species of plants in the quadrats and 90 species of plants present in each year; 16 were new in 1993, and 16 from 1992 were not present in 1993. The scientific and common names of these species are found in Appendix A. As shown in Table 3, the largest number of species, 53, was in Plot 5, and the smallest, 41, was in Plot 1 during 1992; in 1993, the largest number, 59, was in Plot 4, and the smallest, 39, was in Plot 1.

Table 3
Totals and Frequency Results for the Species Found in the Study Areas in the Plots

	No. Species Present		Percent Total Species Present		No. Species with Frequency ≥ 20 Percent		Highest Percent Relative Frequency in the Plot	
Plot No.	1992	1993	1992	1993	1992	1993	1992	1993
1	41	39	44.6	36.1	7	8	9.6	7.9
2	49	52	53.3	48.2	8	8	13.4	10.0
3	48	50	52.2	46.3	10	8	15.0	13.0
4	48	59	52.2	54.6	7	9	17.8	8.1
5	53	51	57.6	47.2	7	9	10.5	7.8
6	45	51	48.9	47.2	7	13	10.4	7.4
7	45	55	48.9	50.9	9	9	11.4	11.3

The plots differed in overall size, elevation, and size of the area used for stacking the trees for burning (the berm). In 1992, the amount of standing water was greatest in Plot 1; all plots were dry during the 1993 study. Plots 6 and 3 had the largest unvegetated areas in 1992, Plots 4 and 5 in 1993; Plots 2 and 4 had 1.2 and 2.5 percent, respectively, less vegetation in 1992 than in 1993; all other plots had increases of from 1.6 (Plot 5) to 44.0 percent (Plot 6). Berm size among the plots varied: Plot 3 was largest; Plot 4 had no berm in transect 8 and was narrower than Plots 1, 2, and 3; smallest in Plots 6 and 7. The berm elevation was conspicuously higher than other areas of the plots. Vegetation on these berms was dominated by *Eupatorium* and species of large, almost pure populations of vines, predominantly *Vigna.*

A cut point for considering the magnitude of times a species was encountered was arbitrarily set at greater than or equal to 20 percent. These numbers of species present per plot were low; five were higher in 1993 and two lower; the number in 1992 was highest at 10 in Plot 3, and in 1993, 13 in Plot 6, indicating that many species were infrequently found in the quadrats (Table 3). In 1992, the highest percent relative frequencies in Plots 1 through 5 were *Eupatorium* and in the last two plots were solitary growing *Baccharis*. In 1993, the highest relative frequencies declined in six of the plots; *Ludwigia octovalvis* was highest in Plots 1 and 2, *Eupatorium* in Plots 3 and 5, *Pluchea* in Plot 4, and *Baccharis* in Plots 6 and 7 (Table 3).

The highest sum of the mean percent cover per square meter of the sampled area per plot was in Plot 1, 87.4 in 1992, 91.8 in 1993; Plot 6 had the lowest in 1992, Plot 5 in 1993 (Table 4). Cover increased in all plots in 1993, most impressively in the herbicide-treated plots, numbers 3, 6, and 7 (Table 4). Few species in any plot had greater than or equal to 75-percent cover (Table 4). Only 8 of the 90 species found in the quadrats had more than 10 percent of possible cover. *Paspalum distichum*, in clumps or dense groups, had over 20 percent of possible cover, which was a reflection of the large frequency and coverage of this species in Plot 1 (Table 5). *Bacopa* had greater cover in more plots in 1993 than in 1992 (Table 5).

Table 4
Percent Cover Values for the Study Areas in the Plots

Plot No.	Sum of Mean Percent Cover/m^2 of Sampled Area		No. Species with a Sum of Cover ≥75 Percent	
	1992	1993	1992	1993
1	87.4	91.8	16	14
2	81.3	89.5	19	14
3	57.9	80.2	12	13
4	57.3	63.3	13	11
5	71.1	77.0	17	14
6	50.4	90.0	11	16
7	55.3	81.2	12	18

Species frequencies greater than or equal to 20.0-percent frequency, relative frequencies, and percentages of possible cover are listed in Table 6. These results show that frequency gives little or no indication of cover when determined in quadrates. A species with very small individuals, such as the small *Baccharis* plants in these sampled plots, can produce high frequency values, even though its cover may be low. Likewise, a species with few individuals but large cover over a considerable portion of the sample area will give low frequencies, as was often evident in the data regarding species of *Cyperus* that grew in clumps or dense groups. Of the species listed in Table 6, certain ones repeatedly occur in the plots. These species can be used to characterize each plot either on the basis of frequency or cover.

Table 5
Species With Greater Than or Equal to 10 Percent of Possible Cover, Growth Form, and Percent of Possible Cover by Plot Number

Plot No.	Species with ≥ 10 Percent of Possible Cover	Dispersion	Percent of Possible Cover	
			1992	1993
1	*Paspalum distichum*	5	21.3	25.2
	Ludwigia peruviana	1	10.5	
2	*Eupatorium*	2	15.4	
	Dactyloctenium	1	10.2	
	Bacopa	4		17.3
	Vigna	5		12.1
3	*Vigna*	5	11.1	14.9
	Eupatorium	2	10.8	10.0
4	*Eupatorium*	2	17.6	
	Pluchea	1		11.2
5	*Bacopa*	4	15.0	12.0
6	*Dactyloctenium*	1	12.7	
	Bacopa	4		13.1
	Vigna	5		11.4
7	*Dactyloctenium*	1	10.7	
	Bacopa	4		14.1
	Baccharis	2		12.9
	Vigna	5		11.2

Note: Blanks are for species not meeting the possible cover criteria.

A matrix of results for calculated similarities of plots based on presence-absence is shown in Table 7. In IS_J, Jaccard's index, equal weight is given to presence and absence of all species. The numerator and denominator change simultaneously. Mueller-Dombois and Ellenberg (1974) state that "experience has shown that there is rarely an IS_J value based on presence which exceeds 50 or 60 percent." Ellenberg's index for percentage cover, IS_E, will be high if the compared plots have common species with high percent coverage. This index reflects not only the number of common and unique species but also the amount of each species present in the plots.

Comparing IS_J values in Table 7, the highest similarities were Plot 5 (Control) and Plot 6 (Velpar at 18.8 L/ha) for 1992, the two herbicide Plots 3 and 7 for 1993. Plots 1 (Manual removal) and 7 (Velpar, 9.38 L/ha) had low similarity indices. Based on presence-absence, the Rodeo herbicide treatments,

Table 6
Species with Frequencies Greater Than or Equal to 20 Percent, Relative Percent Frequencies, and Percent Possible Cover for the Sampled Areas in the Plots

Plot No.	Species with Frequencies ≥ 20.0 Percent	Percent Frequency		Relative Percent Frequency		Percent of Possible Cover	
		1992	1993	1992	1993	1992	1993
1	*Eupatorium*	42.9	30.6	9.6	6.6	5.8	2.4
	Ludwigia octovalvis	42.9	37.1	9.6	7.9	10.5	4.3
	Cyperus surinamensis	32.1		7.3	3.8	0.02	1.1
	Bacopa	25.0	25.8	5.6	5.5	8.2	9.5
	Cyperus polystachos	25.0		5.6	0.3	2.6	0.6
	Dactyloctenium	23.2		5.2	0.0	7.4	0.0
	Paspalum distichum	21.4	33.9	4.8	7.2	21.3	25.2
	Vigna		37.1		7.9		4.3
	Baccharis		30.6		6.6		7.5
	Typha		27.4		5.9		6.2
	Lythrum		21.0		4.5		1.0
2	*Eupatorium*	63.8	40.3	13.4	7.2	15.4	4.5
	Dactyloctenium	39.1		8.2	0.0	10.2	0.0
	Cyperus polystachos	36.2		7.6	2.6	3.1	0.6
	Ludwigia octovalvis	33.3	56.5	7.0	10.0	6.5	9.9
	Polygonum punctatum	29.0	30.6	6.1	5.4	1.9	1.2
	Baccharis	27.5	30.6	5.8	5.4	2.1	3.8
	Cyperus surinamensis	21.7		4.6	2.3	1.9	0.7
	Bacopa	20.3	38.7	4.3	6.9	3.8	17.7
	Vigna		43.5		7.7		12.0
	Cyperus ligularis		24.2		4.3		9.1
	Juncus megacephalus		21.0		3.7		1.2
3	*Eupatorium*	87.3	70.5	15.0	13.0	10.8	10.0
	Cyperus polystachos	47.3		8.1	1.2	3.5	0.2
	Baccharis	41.8	49.2	7.2	9.1	3.1	7.5
	Cyperus surinamensis	34.5		5.9	0.6	1.4	0.1
	Ludwigia octavalvis	34.5	42.6	5.9	7.9	6.6	4.0
	Vigna	30.9	45.9	5.3	8.5	11.1	14.9
	Pluchea	30.9		5.3	3.6	0.8	2.6

(Sheet 1 of 3)

Note: Blanks are for species not meeting the frequency criterion.

Table 6 (Continued)							
Plot No.	Species with Frequencies ≥ 20.0 Percent	Percent Frequency		Relative Percent Frequency		Percent of Possible Cover	
		1992	1993	1992	1993	1992	1993
3	*Dactyloctenium*	25.5		4.4	0.0	1.4	0.0
	Eclipta	25.5		4.4	0.3	1.1	0.1
	Panicum bartowense	21.8		3.7	0.0	1.2	0.0
	Bacopa		27.9		5.1		5.7
	Juncus megacephalus		27.9		5.1		2.3
	Cyperus ligularis		23.0		4.2		9.2
	Polygonum punctatum		21.3		3.9		1.0
4	*Eupatorium*	84.4	37.9	17.8	5.9	17.6	5.6
	Baccharis	43.8	31.0	9.2	4.9	0.9	4.9
	Cyperus polystachos	29.7	20.7	6.3	3.2	2.2	0.5
	Dactyloctenium	29.7		6.3	0.3	1.8	0.1
	Panicum bartowense	26.6		5.6	3.0	8.9	1.9
	Pluchea	21.9	51.7	4.6	8.1	1.6	11.2
	Vigna	21.9	32.8	4.6	5.1	6.5	6.2
	Ludwigia octovalvis		34.5		5.4		3.5
	Phyla		34.5		5.4		3.5
	Bacopa		24.1		3.8		5.1
	Cyperus haspan		24.1		3.8		0.5
5	*Eupatorium*	48.4	41.7	10.5	7.8	6.1	5.8
	Bacopa	36.0	26.7	7.8	5.0	15.0	11.9
	Cyperus surinamensis	25.0		5.4	2.8	1.2	0.4
	Ambrosia	21.9		4.7	1.6	3.0	0.4
	Baccharis	21.9	41.7	4.7	7.8	0.6	5.0
	Panicum bartowense	21.9	20.0	4.7	3.7	5.4	8.0
	Vigna	21.9	38.3	4.7	7.1	5.0	9.5
	Ludwigia octovalvis		40.0		7.4		3.5
	Mikania		35.0		6.5		3.2
	Lythrum		26.7		5.0		2.0
	Cyperus ligularis		20.0		3.7		4.8
6	*Baccharis*	50.8	54.0	10.4	7.4	4.0	9.9
	Cyperus polystachos	42.9		8.7	1.9	1.7	0.4
	Dactyloctenium	42.9		8.7	0.0	12.7	0.0
							(Sheet 2 of 3)

Table 6 (Concluded)

Plot No.	Species with Frequencies ≥ 20.0 Percent	Percent Frequency		Relative Percent Frequency		Percent of Possible Cover	
		1992	1993	1992	1993	1992	1993
6	*Eupatorium*	33.3	31.7	6.8	4.3	0.9	0.8
	Panicum bartowense	28.6		5.8	2.2	8.7	9.0
	Bacopa	23.8	46.0	4.9	6.3	2.0	13.1
	Cyperus surinamensis	20.6		4.2	0.8	0.5	0.4
	Pluchea	20.6	39.6	4.2	5.4	0.7	7.3
	Mikania		34.9		4.8		2.8
	Vigna		33.3		4.6		11.4
	Cynoctonum		30.1		4.1		0.8
	Lythrum		26.9		3.7		0.9
	Ludwigia octovalvis		25.4		3.5		0.9
	Ludwigia microcarpa		23.8		3.3		1.7
	Diodia		22.2		3.0		2.6
	Eleocharis geniculata		20.6		2.8		2.5
	Ipomoea		20.6		2.8		3.6
7	*Baccharis*	49.2	62.5	11.4	11.3	2.2	12.9
	Ambrosia	30.8		7.1	2.8	7.7	1.0
	Cyperus polystachos	30.8		7.1	2.8	3.1	2.2
	Eupatorium	29.2	28.1	6.8	5.1	0.7	1.3
	Dactyloctenium	29.2		6.8	0.0	10.7	0.0
	Cyperus surinamensis	26.2		6.1	2.3	1.1	0.5
	Pluchea	24.6	23.4	5.7	4.2	0.6	1.3
	Cyperus retrosus	20.0		4.6	0.4	0.5	0.2
	Panicum bartowense	20.0		4.6	1.4	5.4	1.8
	Bacopa		42.1		7.6		14.1
	Mikania		32.8		5.9		3.9
	Vigna		31.2		5.6		11.2
	Ludwigia octovavlis		26.5		4.8		2.1
	Cynoctonum		21.8		4.0		1.0
	Salix		20.3		3.7		4.2

(Sheet 3 of 3)

Table 7
Matrix of Similarity Indices of Presence-Absence (IS_J = Jaccard's Formula) and Percent Cover (IS_E = Ellenberg's Formula) for the Seven Study Areas in the Plots

Plot No.	Year	Index	Plot Number 2	3	4	5	6	7
1	1992	IS_J =	52.4	53.6	53.4	46.9	50.9	43.3
	1993	IS_J =	55.9	55.6	49.3	48.3	57.9	48.4
	1992	IS_E =	84.5	65.8	73.9	72.9	72.9	80.3
	1993	IS_E =	88.9	88.8	80.9	85.9	87.7	83.9
2	1992	IS_J =		51.6	47.0	45.7	44.6	46.9
	1993	IS_J =		62.3	52.1	53.0	52.9	55.9
	1992	IS_E =		82.9	73.6	70.0	74.5	72.4
	1993	IS_E =		90.0	76.2	85.2	91.9	89.3
3	1992	IS_J =			62.7	53.0	55.0	55.0
	1993	IS_J =			54.1	55.6	60.3	65.6
	1992	IS_E =			90.4	75.2	99.0	86.4
	1993	IS_E =			77.3	80.7	81.7	82.6
4	1992	IS_J =				62.9	62.3	52.5
	1993	IS_J =				60.9	62.3	56.2
	1992	IS_E =				82.6	95.0	96.4
	1993	IS_E =				83.2	91.5	88.8
5	1992	IS_J =					63.3	55.6
	1993	IS_J =					60.9	62.1
	1992	IS_E =					85.9	79.6
	1993	IS_E =					89.6	89.5
6	1992	IS_J =						60.7
	1993	IS_J =						64.1
	1992	IS_E =						95.2
	1993	IS_E =						92.9

Plots 3 and 4, were 62.7 similar in 1992, 54.1 in 1993. Disking and planting *Taxodium* and *Acer*, Plot 2, resulted in the lowest similarity with Plot 4, Plot 5, Plot 6, and Plot 7 (Table 7). Of the 21 indices, 6 were less than 50, and all were Plots 1 and 2 comparisons, comprising more than 50 percent of all comparisons made for these two plots in 1992; only three comparisons were less than 50, all Plot 1 in 1993. Sixteen comparisons of 1993 data were higher than those of 1992, indicating that there were more species that occurred more frequently in 1993. Four comparisons for 1993 were less than those of 1992, three involving Plot 4.

Comparisons of plot IS_E percent cover indices in Table 7 indicate that the herbicide treatments alone have high percent cover (88.8 to 95.0) similarities; the greatest 1992 similarity was between Plots 3 and 6, both treated with herbicide. Both these plots had low sum of the mean percent cover per square meter, few species with a sum of cover greater than or equal to 75 (Table 4), and the lowest sum of percent cover indicating that there was much exposed soil. For the 1993 data, Plots 6 and 7 (Velpar) were most similar; 15 values were higher than those in 1992, 6 were less, 3 of them involving Plot 4 or

Plot 3, 3 involving Plot 7. The plots have become more similar in percent cover 2 years after treatment. For 1992, Plots 1 and 2 have the greatest similarity with the highest number of plots in the range of 80 to 85 percent (Plots 3 and 7); for 1992, Plots 1, 2, and 5 (control) had the highest percent cover similarities with the greatest number of plots in the range of 70 to 79.6; for 1993, only two comparisons were in the 70s, Plot 4 with 2 and 3 (Table 7). The lowest 1992 similarity of percent cover was between Plots 1 and 3; for 1993, it was Plots 2 and 4 (Table 7). For 1992, Plot 1 had a high mean percent cover per square meter and Plot 3 a much lower amount (Table 4). Plot 1 had a high number of unique species compared with Plot 3. These differences may reflect the results of differences in treatments or water levels.

The values were used in interpretation of frequency and cover data. Statistical analyses of the soils data were conducted in three ways: (a) aggregating the front, berm, and rear data as single results for each plot, including the control uncleared plot, (b) aggregating the front, berm, and rear data as single results for each plot, excluding the uncleared plot, and (c) aggregating the data from all plots, excluding the uncleared plot that had no berm, into front, berm, and rear. Results indicated that when the soils from an uncleared melaleuca plot were included (method 1 above) in the comparisons, this plot differed from Plots 1 through 7 in its lower pH, higher percent organic matter, and higher sulfur content. This uncleared plot differed from all plots except 5 in its exceptionally high magnesium content (1,941 kg/ha compared with 220s) and from Plot 2 in its high cation exchange capacity (25 meq/100 gm compared with 10). Results from method 2 (above) indicated that Plot 5 differed from Plots 2 and 4 in higher percent organic matter and sulfur content. Results from method 3 (above) indicated that the berm area was much higher in phosphorus and potassium than the front and rear areas of the plots. These high values for the berm areas may partially explain the large amount of vegetation consistently found there.

The trees planted in Plot 2 are living and growing. In wetter areas, they are growing at an impressive rate. The millet planted in Plot 3 did not survive, apparently because of the high water level in the site.

Within Plot 1, *Paspalum distichum* had a high percent frequency and the highest percent of possible cover; this plot had no berm and appeared quite different from the other plots, perhaps because of the high 1992 water level. Plot 2 was distinct because of the manual planting of trees. Plots 3, 4, 6, and 7 showed many similarities probably because of the herbicide treatments. Plot 5 appeared intermediate in its vegetation composition from all other plots.

The numbers of melaleuca trees counted within the study area of each plot are listed in Table 8. The Control, Plots 5 and 2, planted with *Taxodium* and *Acer*, contained the largest numbers of trees. The fewest trees were in Plot 1, the wettest plot in 1992; there were three trees, one at the levee end of a transect and the others on the berm. Velpar at 18.8 L/ha, Plot 6, was the most effective herbicide treatment. These melaleuca regeneration counts suggest that since Plot 5, which has 75 trees, was treated as was Plot 1, which has

Table 8
Number of Regenerated Melaleuca Trees In Each Study Area Within the Plots

Plot Number	Number of Trees
1	3
2	62 (71 stems)
3	46
4	31 (58 stems)
5	75 (82 stems)
6	11
7	28

three trees, perhaps the high water level in Plot 1 prevented regeneration of melaleuca. Uprooting, burning the trees, burying seeds by disking, and not applying herbicide will not control regrowth of melaleuca, as was evidenced by the high number of trees in the control, Plot 5 (Table 8). It is not known if the observed trees are the result of seed germination or sprouting from buried wood.

Stem Counts in a Melaleuca Stand

The approximate size of the area counted was 0.386 ha. The approximate mean counts were 223 stems and 13 saplings (trees with stems less than 0.1 m in diameter). The canopy within this plot was closed; there were few other species growing in the area. These observations indicate that the approximate recorded melaleuca counts may represent a maximum number in many habitats in which this species grows.

Stem Counts in Two Melaleuca Stands in Lake Okeechobee

Head one was approximately 0.102 acre (0.041 ha) and contained approximately 204 stems. There were approximately 146 saplings or 176 stems less than 4 in. in diameter. Head two was approximately 0.134 acres (0.054 ha) and contained approximately 532 stems. There were approximately 204 saplings or 256 stems less than 4 in. in diameter.

Regeneration of Melaleuca After Mechanical Clearing

There were a total of 1,238 trees in the 0.0204-ha sampled area. The trees were most frequent near the piles of uprooted trees but extended across a wet ditch toward the levee road. Some measured trees were 3.5 m tall; some trees were in flower.

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Appendix A
Plant Species Present in Sampled Quadrats

Table A1
Plant Species Present in Sampled Quadrats

Scientific Name	Common Name
Alternanthera philoxeriodes (Mart.) Griseb.	Alligator weed
Ambrosia artemisiifolia L.	Common ragweed
Ampelopsis arborea (L.) Rusby	Pepper vine
Andropogon virginicus L.	Broom sedge
Azolla caroliniana Willd.	Mosquito fern
Baccharis halimifolia L.	Eastern baccharis
Bacopa monnieri (L.) Pennel	Water-hyssop
Bidens pilosa L.	Spanishneedles
Canna flaccida Small	Canna
Cardiospermum halicacabrum L.	Ballonvine heartseed
Cenchrus echinatus L.	Sand bur
Centella asiatica (L.) Urban	Spadeleaf
Ceratopteris pteridoides (Hook) Hieron	Floating antler fern
Chamaesyce hyssopifolia (L.) Small	Spurge
Chloris glauca (Chapm.) Wood	Saltmarsh chloris
Chloris petraea Sw.	Tumbleweed windmillgrass
Cicuta mexicana Coult. & Rose	Common waterhemlock
Colocasia esculentum (L.) Schott.	Taro
Commelina diffusa Burm. f.	Spreading dayflower
Conoclinium coelestinum (L.) DC.	Mist flower
Croton glandulosus L.	Croton
Cynoctonum mitreola (L.) Britt.	Lax hornpod
Cyperus distinctus Steud.	Flatsedge
Cyperus haspan L.	Sheathed cyperus
Cyperus ligularis L.	Cyperus
Cyperus odoratus L.	Fragrant flatsedge
Cyperus pollardii Britt. ex Small	Sedge
Cyperus polystachos Steud.	Many-spiked flatsedge
Cyperus retrorus Chapm.	Nutsedge
Cyperus surinamensis Rottb.	Tropical flatsedge
Dactyloctenium aegyptium (L.) Richt.	Crowfoot grass
Dichromena colorata (L.) Hitch.	White top
Diodia virginiana L.	Virginia buttonweed
Echinocloa crusgalli (L.) Beauv.	Barnyard grass

(Sheet 1 of 4)

Table A1 (Continued)

Scientific name	Common name
Eclipta alba (L.) Hassk.	Common yerbadetajo
Eichhornia crassipes (Mar.) Solms	Waterhyacinth
Eleocharis cellulosa Torr.	Gulfcoast spikerush
Eleocharis geniculata (L.) R. & S.	Spikerush
Emilia fosbergii D. H. Nicholson	Tasselflower
Erechtites hieracifolia (L.) Raf.	Fireweed
Erigeron strigosus Muhl.	Daisy fleabane
Eupatorium capillifolium (Lam.) Small	Dog-fennel
Fimbristylis autumnalis (L.) R. & S.	Slender fimbristylis
Fuirena squarrosa Michx.	Hairy umbrella-sedge
Gallium tinctorum L.	Bye bedstraw
Gaura angustifolia Michx.	Southern gaura
Hydrilla verticillata (L.f.) Royle	Hydrilla
Hydrocotyle umbellata L.	Umbrella pennywort
Ipomoea alba L.	Moon flower
Iresine celosia L.	Iresine
Iris pseudacorus L.	Yellow iris
Juncus biflorus Ell.	Turnflower
Juncus megacephalus M. A. Curtis	Largeheaded rush
Juncus trigonocarpus Stued.	Triangular-fruited rush
Kosteletzkya virginiana (L.) Presl. ex Gray	Seashore-mallow
Lemna sp.	Duckweed
Limnobium spongia (Bosc.) Steud.	American frogbit
Lingernia anagallidea (Michx.) Pennell	Clasping falsepimpernel
Ludwigia linearis Walt.	Narrowleaf seed-box
Ludwigia microcarpa Michx.	Small fruited waterprimrose
Lugwigia octovalvis (Jacq.) Raven	Shrubby waterprimrose
Ludwigia repens Forst.	Marsh purslane
Lythrum alatum var. lanceolatum (Ell.) T. & G.	Winged lythrum
Melaleuca quinquenervia (Cav.) Blake	Punk tre
Mikania scandens (l.) Willd.	Hemp-weed
Momordica charantia L.	Wild balsam apple
Myrica cerifera L.	Wax-myrtle
Panicum bartowense Scribn.	Bartow panicum

(Sheet 2 of 4)

Table A1 (Continued)

Scientific name	Common name
Panicum virgatum L.	Switchgrass
Paspalum distichum L.	Knotgrass
Paspalum fimbriatum HBK.	Panama paspalum
Paspalum setaceum Michx.	Thin paspalum
Phragmites australis (Cav.) Trin. ex Steud.	Giant cane
Phyla nodiflora Michx.	Common frog-bit
Physalis viscosa L.	Groundcherry
Pluchea rosea R. K. Godfrey	Purple pluchea
Poinsettia heterophylla (L.) Kl. & Gke.	Poinsettia
Polygala incarnata L.	Milkwort
Polygonum densiflorum Meisn.	Southern smartweed
Polygonum punctatum Ell.	Dotted smartweed
Pontederia cordata L.	Pickerelweed
Portulaca pilosa L.	Purslane
Psilocarya nitens (Vahl.) Wood	Short-beaked bald rush
Ptilimnium capillaceum (Michx.) Raf.	Mock bishopweed
Rhyncholytrum repens (Willd.) C. E. Hubbard	
Rotala ramosior (L.) Koehne	Tooth-cup
Sabatia campanulata (L.) Torr.	Bell shaped sabatia
Sacciolepis striata (L.) Nash	American cupscale
Sagina decumbens (Ell.) T. & G.	Trailing perlwort
Sagittaria lancifolia L.	Bulltongue
Salix caroliniana Michx.	Coastal plain willow
Scirpus validus L.	Softstem bullrush
Scoparia dulcis (Ell.) T. & G.	Sweet broomwort
Sesbania sp.	Rattle box
Setaria geniculata (Lam.) Beauv.	Knotroot bristlegrass
Setaria glauca (L.) Beauv.	Yellow foxtail
Sida spinosa L.	Indian mallow
Solanum sp.	Nightshade
Solidago sp.	Goldenrod
Spondias purpurea L .	Hog plum
Sporobolus domingensis (Lam.) Hitch.	Dropseed
Taxodium distichum (L.) Richard	Common baldcypress

(Sheet 3 of 4)

Table A1 (Concluded)

Scientific name	Common name
Teucrium canadense L.	Germander
Typha latifolia L.	Common cattail
Verbena scabra Vah.	Verbena
Vigna luteola (Jacq.) Benth.	Yellow cowpea
	(Sheet 4 of 4)

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13. ABSTRACT *(Maximum 200 words)*
Seven approximately 3.3-ha plots were established near Moore Haven, FL, along the southwest Lake Okeechobee levee road. After mechanical uprooting, stacking, and burning all melaleuca trees, the areas were harrowed with a disk. Two plots were treated with Rodeo herbicide, two with Velpar L, one was planted with common baldcypress (*Taxodium distichum* (L.) Richard) and red maple (*Acer rubrum* L.), one was a control with no further treatment, and one had regrowth melaleuca manually removed. One and two years later, results of the these treatments were assessed using transect lines and quadrats. A total of 106 species of plants were found; 90 species each study year were within the quadrats, 16 new in 1993, and 16 absent from the 1992 study. Frequency of species and percent cover increased from 1992 to 1993. Dog-fennel (*Eupatorium capillifolium* (Lam.)) small and eastern baccharis (*Baccharis hamilifolia* L.) were cover dominants and most frequent in 1992; these two species were most frequent in 1993 with a variety of species cover dominants. Soil analyses indicated that the control plot differed from the plant and Rodeo herbicide plot in higher percent organic matter and sulfur content. The berm area where the trees were burned was higher in phosphorus and potassium than other areas of the plots. The control plot had the most melaleuca regrowth. The fewest melaleuca trees (three) were counted in the study area of Plot 1, which was not treated with herbicide; it is possible that the 1992 high water level in this plot may have prevented tree regrowth. The highest concentration of Velpar L herbicide treatment plot had 11 trees, the second fewest.

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