Appendix G

Invasive Plant Species Control Plan

45TH SPACE WING
DRAFT
INVASIVE PLANT SPECIES CONTROL PLAN (2014)

Cape Canaveral Air Force Station, Patrick Air Force Base, Malabar Tracking Annex and Jonathan Dickinson Missile Tracking Annex

ACRONYM LIST

45 SW	45th Space Wing
AFCEE	Air Force Center for Environmental Excellence
AFSPC	Air Force Space Command
AI	Active Ingredient
APHIS	Animal and Plant Health Inspection Service
BMP	Best Management Practice
BP	Brazilian Pepper
CCAFS	Cape Canaveral Air Force Station
CEQ	Council on Environmental Quality
CES/CEIE-C	Civil Engineer Squadron, Environmental Conservation Element
CG	Cogon Grass
dbh	diameter at breast height
DOD	Department of Defense
DODI	Department of Defense Instruction
EIAP	Environmental Impact Analysis Process
EO	Executive Order
ESRS	Exotic Species Ranking System
FLEPPC	Florida Exotic Pest Plant Council
GPS	Global Positioning System
INRMP	Integrated Natural Resources Management Plan
JDMTA	Jonathan Dickinson Missile Tracking Annex
KSC	Kennedy Space Center
LRPG	Long Range Proving Ground
MINWR	Merritt Island National Wildlife Refuge
MTA	Malabar Tracking Annex
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NOTU	Naval Ordnance Test Unit
NPS	National Park Service
UF	University of Florida
US	United States
USACE	United States Army Corps of Engineers
USAF	United States Air Force
USC	United States Code
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
USN	United States Navy

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Executive Summary

This Invasive Species Control Plan (ISCP) was developed to support the 45th Space Wing Civil Engineer Squadron, Environmental Conservation Element Environmental Conservation (45 CES/CEIE-C) natural resources program management. This ISCP was originally developed in 2005 and updated in 2006/2007. This ISCP is a living document and is regularly revised to update data for existing invasive species with the latest available information, as well as incorporate information on any new invasive species identified. Several species of invasive plants are included in this revised ISCP incorporating additional species since the last update. This ISCP is to be used in conjunction with the 45 SW Integrated Pest Management Plan.

This ISCP covers invasive and noxious plant species of concern on 45th Space Wing (45 SW) mainland Florida properties as identified by the Florida Noxious Weeds List (https://www.flrules.org/gateway/ruleno.asp?id=5B-57.007&Section=0), and Florida Exotic Pest Plant Council 2013 List of Invasive Plant Species (http://www.fleppc.org/list/list.htm), control priorities and recommendations, and prevention and control methods. 45 CES/CEIE-C has identified the following priority invasive plant species for management:

- Brazilian pepper (*Schinus terebinthifolius*)
- Australian pine (*Casuarina equisetifolia*)
- Cogon grass (*Imperata cylindrica*)
- Torpedo Grass (*Panicum repens*)
- Melaleuca (*Melaleuca quinquenervia*)
- Mimosa (*Albizia julibrissin*)
- Hydrilla (*Hydrilla verticillata*)
- Earleaf acacia (*Acacia auriculiformis*)
- Chaste tree (*Vitex trifolia*)
- Common guava (*Psidium guajava*)
- Old World climbing fern (*Lygodium microphyllum*)
- Schefflera (*Schefflera actinophylla*)
- Wedelia (*Sphagneticola trilobata*)

1.0 Introduction

Federal agencies are required under Executive Order (EO) 13112 of February 3, 1999 - Invasive Species, the Sikes Act, as amended (16 United States Code [U.S.C.] 670), and various other federal and state regulations and policies to control invasive species on their properties and to reduce their ecological and economic impact. EO13112 directs federal agencies "to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause". The EO defines an "invasive species" as "an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health".

Invasive plants may replace native plants by spreading aggressively and successfully competing for light, water, and nutrients. In cultivated environments, invasive species reduce crop yields and quality. In natural environments, invasive species may alter the forage regime of wildlife, choke waterways, alter soil resources, reduce the quality of a recreational experience, and/or modify the fire regime.

Most invasive plants are pioneer species that colonize disturbed areas such as roadsides, cleared areas, construction sites, Rights-of-way, utility corridors and landfills. These plants generally possess attributes that contribute to their ability to replace native plants including, rapid growth, and regeneration from seed and/or vegetative propagation, early maturation, prolific reproduction, and some may even have allelopathic effects (producing toxins that prevent establishment of rival species). Invasive plants with origins far from the site of their introduction may lack natural predators and spread aggressively. Invasive species may create a monoculture, replacing all other species in an area and preventing the establishment of native vegetation. Even though invasive plant species are sometimes deliberately introduced, an abundance of invasive plants in an area will usually reduce the value of the land for agricultural and wildlife resources.

This ISCP describes the invasive plant species present at four 45 SW installations in Florida: Cape Canaveral Air Force Station (CCAFS), Patrick Air Force Base (PAFB), Malabar Transmitter Annex (MTA), and Jonathan Dickinson Missile Tracking Annex (JDMTA). The Plan also details management techniques that will be employed to control and ultimately eradicate invasive plant species. This ISCP is to be used in conjunction with the INRMP, which includes information for these sites about threatened and endangered species (Sections 5.4 and 7.5; and in Appendix C), vegetative communities (Sections 5.2 and 7.9; and in Appendix D), wildland fire (Section 7.10 and in Appendix J), and the goals and objectives for invasive species management for the 45 SW are presented in Chapter 8. Overall facility overviews are presented in Chapter 3, physical environment overviews in Chapter 4 and biological environment overviews in Chapter 5 of the INRMP.

Table G-1 is a current list of Florida noxious weeds and exotic invasive plant species categorized by the Florida Exotic Pest Plant Council (FLEPPC 2013) and found on 45th Space Wing (45 SW) properties: Cape Canaveral Air Force Station (CCAFS), Patrick Air Force Base (PAFB), Malabar Transmitter Annex (MTA) and Jonathan Dickinson Missile Tracking Annex (JDMTA).

Table G-1. List of Noxious and Invasive Plant Species on 45SW Properties									
Common Name	Scientific Name	FLEPPC Category[1]		Listed Noxious Species[2]	45 SW Priority	Occurs on Installation			
		I	II			CCAFS	PAFB	MTA	JDMTA
Air potato	*Dioscorea bulbifera*	✓		✓	Medium	✓			
Alligator weed	*Alternanthera philoxeroides*		✓		Low			✓	
Australian pine	*Casuarina equisetifolia*	✓		✓	High	✓	✓	✓	
Brazilian pepper	*Schinus terebinthifolius*	✓		✓	Very High	✓	✓	✓	✓
Camphor tree	*Cinnamomum camphora*	✓			Low			✓	
Carrotwood	*Cupaniopsis anacardioides*	✓		✓	Medium			✓	
Castor bean	*Ricinus communis*		✓	✓	Medium	✓			
Chaste tree	*Vitex trifolia*		✓		High	✓	✓	✓	
Chinese tallow tree	*Sapium sebiferum*	✓		✓	Medium			✓	
Cogon grass	*Imperata cylindrica*	✓		✓	Very High	✓	✓	✓	✓
Common guava	*Psidium guajava*	✓			High	✓		✓	
Earleaf acacia	*Acacia auriculiformis*	✓			High	✓			✓
Elephantgrass	*Pennisetum purpureum*	✓			Low	✓			
Hydrilla	*Hydrilla verticillata*	✓			Low		✓		
Java plum	*Syzygium cumini*	✓			Low			✓	
Lantana	*Lantana camara*	✓		✓	Medium	✓		✓	
Melaleuca	*Melaleuca quinquenervia*	✓		✓	High	✓	✓	✓	✓
Mimosa	*Albizia julibrissin*	✓			High	✓	✓	✓	
Natal grass	*Melinis repens*	✓			Medium	✓		✓	✓
Old World climbing fern	*Lygodium microphyllum*	✓		✓	High			✓	
Paragrass	*Urochloa mutica*	✓			Medium	✓		✓	
Peruvian primrose willow	*Ludwigia peruviana*	✓			Medium	✓		✓	
Rattlebox	*Sesbania punicea*		✓		Low			✓	
River sheoak	*Casuarina cunninghamiana*		✓		Low	✓			
Rosary pea	*Abrus precatorius*	✓		✓	Medium	✓		✓	✓

Table G-1. List of Noxious and Invasive Plant Species on 45SW Properties

Common Name	Scientific Name	FLEPPC Category[1]		Listed Noxious Species[2]	45 SW Priority	Occurs on Installation			
		I	II			CCAFS	PAFB	MTA	JDMTA
Schefflera	*Schefflera actinophylla*	✓			High				✓
Surinam cherry	*Eugenia uniflora*	✓			Low	✓			
Torpedo grass	*Panicum repens*	✓			High	✓	✓	✓	
Wedelia	*Sphagneticola trilobata*		✓	✓	High		✓		
Wild balsam apple	*Momordica charantia*		✓		Low	✓		✓	
Wild bushbean	*Macroptilium lathyroides*		✓		Low	✓		✓	

Source: USDA-NRCS 2014, VZ Technologies et al. 2014, FLEPPC 2013, Reyier et al. 2011, Gulledge et al. 2009

[1] FLEPPC Ranking:

CATEGORY I = Invasive exotics that are altering native plant communities by displacing native species, changing community structures or ecological functions, or hybridizing with natives.

CATEGORY II = Invasive exotics that have increased in abundance or frequency but have not yet altered Florida plant communities to the extent shown by Category I species.

[2]Noxious and invasive species as listed in FL Rule 5B-57.007 Noxious Weed List

2.0 Site Descriptions

Cape Canaveral Air Force Station (CCAFS)

CCAFS encompasses approximately 16,198 acres that consist of developed areas and undeveloped areas. A full site description is provided in the INRMP, Chapter 3, Installation Overview. Maps of the installation are available in the INRMP as well in Figures 3-1, 3-2, 4-2, 4-6, and 5-1. The current land use is described in Section 3.2 of the INRMP; and the vegetative communities are presented in Section 5.2 of the INRMP and in Appendix D. Select areas throughout the installation have been treated mechanically and burned to restore habitat to its desirable height and vegetative composition. An added benefit of treating with fire is the suppression of invasive plants, such as Brazilian pepper (*Schinus terebinthifolius*) and the reduction of fuel loads.

Most of the areas within CCAFS that have been disturbed, including roads, utility corridors, and launch complexes, have an invasive species component predominated by Brazilian pepper. The dominant vegetation in developed industrial areas is comprised of turf grasses and landscape trees and shrubs. Melaleuca (*Melaleuca quinquenervia*) is also found in isolated areas around CCAFS as they were used as landscape trees in the past. The areas located adjacent to the north of CCAFS contain the same vegetative species as those found throughout the undeveloped areas within CCAFS. Vegetation on south of CCAFS changes due to the presence of a developed port and residential development.

Patrick Air Force Base (PAFB)

PAFB encompasses approximately 2,002 acres that consist primarily of developed areas, with some undeveloped areas. A full site description is provided in the INRMP, Chapter 3, Installation Overview. Maps of the installation are available in the INRMP as well in Figures 3-1, 3-3, 4-3, 4-7, and 5-2. The current land use is described in Section 3.2 of the INRMP; and the vegetative communities are presented in Section 5.2 and Appendix D of the INRMP.

Brazilian pepper is the primary invasive exotic species of concern with PAFB, but good control has reduced the number of locations (and seed sources) to just a few areas (i.e. area near the FamCamp). Other invasive plant species of concern include: cogon grass (*Imperata cylindrical*) in the airfield; wedelia (*Wedelia trilobata*) along the Banana River and chaste tree (*Vitex trifolia*) is a large hedge growing along the beach. Melaleuca trees and Australian pine (*Casuarina equisetifolia*) are found within the PAFB golf course. (Keitha Datillo-Bain, personal communication 29 October 2013)

Malabar Transmitter Annex (MTA)

MTA encompasses approximately 640 acres that is primarily developed and is completely surrounded by a residential subdivision. A full site description is provided in the INRMP, Chapter 3, Installation Overview. Maps of the installation are available in the INRMP as well in Figures 3-1, 3-4, 4-4, 4-8, and 5-3. The current land use is described in Section 3.2 of the INRMP; and the vegetative communities are presented in Section 5.2 and Appendix D of the INRMP. Undeveloped areas are comprised of mesic flatwoods, wet flatwoods and some small depression marshes, as well as a network of drainage ditches. These areas have been disturbed to some degree and exotic vegetation is distributed throughout.

Jonathan Dickinson Missile Tracking Annex (JDMTA)

JDMTA encompasses 11 acres of land leased from Jonathan Dickinson Florida State Park. The State Park is comprised of xeric uplands, mesic to dry flatwoods, and forested/herbaceous wetlands, while the remaining area is residential. JDMTA has some rosemary scrub and sand pine islands scattered within its boundaries. A full site description is provided in the INRMP, Chapter 3, Installation Overview. Maps of the installation are available in the INRMP as well in Figures 3-1, 3-5, 4-5, 4-9, and 5-4. The current land use is described in Section 3.2 of the INRMP; and the vegetative communities are presented in Section 5.2 and Appendix D.

3.0 Invasive and Noxious Plant Species on 45 SW Installations

This section describes the identification, origin, and distribution for priority invasive plant species found on 45 SW installations in Florida.

3.1 Brazilian pepper (*Schinus terebinthifolius*)

Brazilian pepper is the most problematic invasive plant species within the 45 SW and is found at all 45 SW installations. It is listed as a Category I invasive exotic species by the Florida Exotic Pest Plant Council (FLEPPC). This means that it is known to be "altering native plant communities by displacing native species, changing community structure" (FLEPPC 2013). At most installations Brazilian pepper has dominated roadsides and disturbed areas. Along roadsides the plant forms a dense perimeter that gives way to native vegetation within 50 to 100 feet of the mowed area along the roadways. In disturbed areas the species is found as both isolated individuals and more extensive infestations. According to the protocol in the *Handbook for Ranking Exotic Plants for Management and Control*, the significance of impact for Brazilian pepper is the highest of those invasive and noxious plant species found on the 45 SW (Hiebert and Stubbendieck 1993). This species is also one of the most difficult invasives to control.

3.1.1 Identification

Brazilian pepper is a member of the Anacardiaceae (cashew/sumac) family. Other common names include pepper tree, Florida holly, and Christmas berry. Brazilian pepper is an evergreen shrub or small tree up to 33 feet tall with a short trunk usually hidden in a dense head of contorted, intertwining branches (Photo 1). The leaves have a reddish, winged midrib, with three to 13 sessile, oblong or elliptic, finely toothed leaflets that are one to two inches long (Photo 2). The plants have male and female flowers, found on separate plants with flowering occurring any season (primarily September through November). The flower clusters are two to three inches long; male and female flowers are similar; both are white, and are made up of five parts with ten stamens in two rows of five. The flowers also have a lobed disc within the stamens. The fruits are in clusters which are glossy, green, and juicy at first, becoming bright red when ripe. The red skin dries to become a papery shell surrounding the seed, which is dark brown and 0.01 inches in diameter.

Photo 1. Brazilian pepper tree.

Photo 2. Brazilian pepper leaves and fruit.

3.1.2 Origin and Distribution

Brazilian pepper originated from Brazil, Argentina, and Paraguay. It has naturalized in most tropical and subtropical regions and can be found in South and Central America, Bermuda, the Bahamas, the West Indies, Guam, Mediterranean Europe, North Africa, southern Asia, and South Africa. It was imported to the United States (U.S.) in the 1840s as an ornamental and has invaded fallow farmland, pinelands, hardwood hammocks, roadsides, and mangrove forests. In the U.S., Brazilian pepper can be found in Hawaii, California, southern Arizona, and Florida. In Florida, it reaches as far north as Levy and St. Johns Counties and as far west as Santa Rosa County.

Brazilian pepper can readily invade areas with a high degree of disturbance or natural areas that have had little or no disturbance (Francis 2002). On the 45 SW, this species has readily invaded abandoned launch sites, the sides of roadways, utility corridors, Lines of Sight and other disturbed areas (Photos 3 and 4).

Photo 3. Brazilian pepper along a road.

Photo 4. Brazilian pepper infestation at an abandoned launch facility.

Brazilian pepper forms dense, tangled thickets that completely shade out and displace native vegetation. Seeds are spread by wildlife, especially birds, through consumption of fruit and deposition. The pepper sprouts easily from the trunk and roots even when undamaged.

Brazilian pepper and poison ivy are both members of the Anacardiaceae family. The Brazilian pepper may produce allelopathic agents that can suppress other plants' growth and irritate human skin and respiratory passages. Contact with most parts of plant can cause an itchy skin rash. Sometimes inflammation and swelling of the face and eyes occurs. The flowers and fruits can cause respiratory irritation and ingestion of the berries causes vomiting. Proper protective gear should be used when attempting control of this species.

3.1.3 Management Options for Brazilian Pepper

3.1.3.1 Physical Control - Manual/Mechanical Methods

Heavy equipment such as bulldozers, front-end loaders, root rakes, cutter heads, and other specialized equipment may be used for mechanical control of Brazilian pepper. Mechanical control works well along ditch banks, utility rights-of-way, and other previously disturbed areas. However, this is not an ideal method for control in a natural environment due to extensive soil disturbance. On the 45 SW it is more effective to cut the large areas of Brazilian pepper and then burn the cut material and apply herbicides to stumps to prevent regrowth. A follow-up application of herbicide is usually required at 3 and 6 month intervals to treat plants not previously killed and new plants that

may have germinated from seeds dropped from the plant. A chain saw or a Vee blade attached to a bulldozer should be used to cut the trunk as close to the ground as possible. Proper protective gear should be used when attempting control of this species (e.g., thick leather gloves, long sleeve shirts, long pants). The best time to cut the trees is when they are not fruiting to reduce the spread of seeds/berries; March through October. If the Brazilian pepper has seeds (red berries) attached, they should not be disturbed until they have been treated with the appropriate herbicide (systemic) and allowed to die. Information about herbicides is provided in section 3.1.3.5 of this Appendix G, and in section 7.12 of the INRMP.

3.1.3.2 Physical Control - Prescribed Burning

Brazilian pepper does not burn readily (FSL 2002); therefore, prescribed burning is not an effective means of control. This species forms dense thickets that fire rarely penetrates. It produces new leaves throughout the year and the high moisture content of the leaves and wood make it difficult to burn. When it does burn, the aboveground parts are killed, but the tree promptly re-sprouts from the base. Brazilian pepper is able to regenerate after burning by sprouting from the root or root collar resulting in more stem production than originally existed prior to the burn (Ewel 1986).

Brazilian pepper forests alter natural fire regime. Research has shown that burning is not an effective method for controlling mature stands, but may affect Brazilian pepper seeds, seedlings, and saplings. Five-year fire intervals appear to increase Brazilian pepper mortality in limestone-rockland pine forests in southern Florida. Fire management programs that kill seedlings less than three feet tall can keep a forest relatively free of Brazilian pepper. In addition, Brazilian pepper belongs to the same family as poison ivy, so the sap and smoke from burning may cause irritation and/or an allergic reaction.

3.1.3.3 Biological Control - Insects/Pathogens

As of 2003, over two hundred insects have been identified in the Brazilian pepper tree's native land. These may be useful for control of Brazilian pepper, but no biological controls have been released for use in the U.S. (Vandaveer 2003). University of Florida (UF) scientists have identified two insect species that may prove to be effective biological control agents, a sawfly (*Heteroperreyia hubrichi*) and a thrips (*Pseudophilothrips ichini*). The sawfly causes defoliation and the thrips feeds on new shoots, however, neither species has been recommended for field release due to uncertainty in species definition and concern over negative impacts associated with larval toxicity on native fauna, respectively (UF 2013). An introduced species of wasp has also been identified the Brazilian pepper-tree seed chalcid (*Megastigmus transvaalensis*) that may help with control of Brazilian pepper; this species was found in Palm Beach County emerging from pepper-tree fruits in 1988 (Cuda et al. 2004). The female wasp lays one or two eggs in a fruit shortly after the tree has flowered; as a result the seeds of infested fruits do not germinate. At this time this is not a feasible control method for use on Brazilian pepper at the 45 SW.

3.1.3.4 Biological Control - Grazing

Herbivorous animals are not known to feed on Brazilian pepper and grazing is not a recommended control method for this species.

3.1.3.5 Herbicide Control

Herbicides are available that will control Brazilian pepper (Table 1). Only those herbicides labeled for Brazilian pepper control should be used. In addition, all pesticides used on 45 SW installations must be approved by AFCEC.

Brazilian pepper can be controlled by cutting them down and treating the stumps with herbicide. A saw should be used to cut the trunk as close to the ground as possible. Within twenty minutes of cutting, an herbicide that contains the active ingredient glyphosate or triclopyr should be applied as carefully as possible to the freshly cut stump. These herbicides are systemic, which means they are

taken up by the plant and distributed throughout the plant effectively killing the whole plant. Care should be taken to avoid touching the fresh cut area as a skin rash may result. Triclopyr is registered for use in Florida, and is approved for use on the 45 SW through a waiver from USAF Space Command. Glyphosate is on the Department of Defense (DoD) and US Air Force Space Command (AFSPC)-approved list of herbicides (DoD 2004). Table 1 identifies recommended herbicides and application methods. Table G-1 identifies those herbicides recommended for the management of Brazilian pepper at the 45 SW.

Table G-2. Recommended Herbicides and Application Methods for Management of Brazilian Pepper

Active ingredient (based on the acid)	**Products**	**Application Methods**	**Comments**
Glyphosate (four pounds per gallon or spray-to-wet 1.5 percent solution)	Rodeo® Aquamaster™ Glypro™ Plus	Cut stump when not flowering, or spray-to-wet seedlings with 1.5 percent solution in hand-held equipment	Available from agricultural suppliers. May be applied directly to water. Provides partial control
Glyphosate (3.7 pounds per gallon)	Roundup® Weed & Grass Killer Super Concentrate	Cut stump when not flowering, or foliar spray-to-wet seedlings with hand-held equipment	Available from retail garden suppliers. May **not** be applied directly to water. Provides partial control.
Glyphosate (three pounds per gallon, or broadcast two to five quarts per acre, or spray-to-wet 1.5 percent solution)	Roundup Pro® Glyfos® Pro	Cut stump when not seeding, or spray-to-wet seedlings with 1.5 percent solution in hand-held equipment	Available from agricultural suppliers. May **not** be applied directly to water. Provides partial control
Triclopyr amine (three pounds per gallon)	Garlon 3A Renovate	Cut stump Foliar	Available from agricultural suppliers. May be applied directly to water.
Triclopyr amine (0.59 pounds per gallon)	Enforcer Brush Killer	Cut stump Foliar	Available from retail garden suppliers. May **not** be applied directly to water.
Triclopyr amine (0.54 pounds per gallon)	Ortho Brush-B-Gon	Cut stump Foliar	Available from retail garden suppliers. May **not** be applied directly to water.
Triclopyr ester (four pounds per gallon)	Garlon 4	Cut stump Foliar Basal bark	Available from agricultural suppliers. May **not** be applied directly to water.
Triclopyr ester (0.75 pounds per gallon)	Pathfinder II	Cut stump Basal bark	Available from agricultural suppliers. May **not** be applied directly to water.
Triclopyr ester (0.75 pounds per gallon)	Vine-X	Cut stump Basal bark	Available from retail garden suppliers. May **not** be applied directly to water.

(Sources: Gioeli and Langeland 2003 and product labels)
*Triclopyr is not approved for use on North American Air Force bases but has been granted a waiver for 45 SW (DOD 2004).

Fruiting trees can be controlled using a basal bark herbicide application. An herbicide product that contains triclopyr ester, such as Garlon 4® with a penetrating oil or Pathfinder II® pre-mixed with penetrating oil, should be applied to the Brazilian pepper's bark between six inches and one foot

from the ground. Since the herbicide will pass through the bark, girdling the tree's trunk is not necessary and may reduce the effectiveness. After treatment, it may take several weeks before there is evidence that the tree has been treated. Defoliation and the presence of termites is an indicator that the treatment has been successful.

Basal bark treatments are most effective in the fall when the Brazilian pepper is in flower. Fruiting occurs during winter and Brazilian pepper trees that have been treated with a basal bark treatment may retain their fruit. The area will need to be checked for the germination of seeds/seedlings on a regular basis.

Foliar herbicide application can be used on Brazilian pepper seedlings and smaller plants. An herbicide containing triclopyr or glyphosate can be applied directly to the tree's foliage. The leaves will wilt and the herbicide will be translocated to other parts of the tree. Foliar applications require considerably more herbicide. However, a relatively new technique called "lacing" employs the use of herbicides Triclopyr and Imazapyr in very low concentration (1.5% and 0.5% respectively). The chemicals are blended with water and a carrier which is an animal rendered oil and mixed in a unit that operates much like a food processor. The oil surrounds the water mixture and is sprayed out in as a thick gooey substance that adheres to the leaf surface with little if any over spray. The material has been tested by the UF Institute of Food and Agricultural Sciences on non-target native species which have a thick waxy cuticle layer with little or no harm to these species.

3.2 Australian pine (*Casuarina equisetifolia*)

Australian pine was found at CCAFS throughout the installation in small populations (usually not greater than 1.5 acres in size). Australian pine is listed as a Category I invasive exotic species by the FLEPPC. According to the protocol in the *Handbook for Ranking Exotic Plants for Management and Control*, the significance of impact for Australian pine is medium and this species is moderately hard to control (Hiebert and Stubbendieck 1993). This species is also found along the canals that surround MTA, and is also found within PAFB.

3.2.1 Identification

Australian pine is a member of the Casuarinaceae family (Beefwood family). Other common names include ironwood, beefwood, she oak, Polynesian ironwood, and horsetail tree. The tree is deciduous with a soft, wispy, pine-like appearance that can grow to 100 feet or more in height (Photo 5). It bears a superficial resemblance to the conifer genus *Pinus* because of its small, round, cone-like fruits, although it is not related to pine trees. The branchlets of scale-like leaves also look like pine needles, however, they are made up of individual segments, which make them readily identifiable in the field (Photo 6). The flowers are tiny, brown, and wind-pollinated. The fruit is a nutlet about ½ inches in diameter that contains winged seeds (Swearingen 1999; Dommergues 1990).

3.2.2 Origin and Distribution

Australian pine trees were observed by botanists in Mexico prior to 1852. They were introduced into Barbados about 1870, Hawaii before 1895, and naturalized in the West Indies and Florida before 1920. Australian pine is also established in Puerto Rico, the Bahamas, and many Caribbean islands (Elfers 1998).

Photo 5. Australian pine trees.

Photo 6. Australian pine needles.

Australian pine is probably one of the most invasive species in south Florida. It freely self seeds in disturbed areas, and once established, may inhibit the growth of native species. It occurs throughout south Florida, from Orlando south, on sandy shorelines, pinelands, and in the Everglades, above the water table or at the mean high waterline. It frequently colonizes disturbed sites, such as filled wetlands, road shoulders, cleared land, and vacant lots. Although Australian pine cannot tolerate prolonged flooding, it is extremely resistant to salt spray, and grows rapidly during hot weather. It is rarely seen in northern Florida since it is intolerant of long periods of cold weather.

Australian pine is an extremely aggressive and densely rooted species. Once established this species may inhibit the growth of native species by forming dense stands that smother its competitors under a heavy blanket of needle-like litter. Monocultural stands will displace sand-binding native dune and beach vegetation. This increases coastal erosion, causes changes in soil chemistry and degradation to wildlife habitat, and in general, can drastically alter coastal environments. Few animals can survive in the ecologically barren shelter of an Australian pine forest.

Australian pine has a phenomenal growth rate that outpaces most other plants. It can reproduce by thousands of windborne seeds per plant or by coppicing. This produces close, impenetrable, monotypic stands that harbor few native plants or animals.

3.2.3 Management Considerations and Options

Present eradication methods are costly and require many man-hours for implementation. Invasion opportunities can be reduced by avoiding disturbance of natural habitats or replanting natural vegetation as quickly as possible when areas have been disturbed. Maintaining natural fire regimes and allowing periodic flooding can help to combat this invasive species.

Australian pine has no natural enemies in North America and no biological controls are currently available for management. Manual removal of Australian pine seedlings and saplings is recommended for new or small infestations. Heavier infestations will require an application of a systemic type herbicide to bark, cut stumps, or foliage for effective management. Prescribed burning has worked for large infestations in fire-tolerant communities.

3.2.3.1 Physical Control - Manual/Mechanical Methods

Manual removal is best for new or small infestations of seedlings, saplings, and young trees. Raking and removal of leaf litter, cones, and seeds should be done whenever possible. After removal the vegetation may be piled together and burned or disposed of offsite.

3.2.3.2 Physical Control - Prescribed Burning

Prescribed burning has been used for large infestations in fire-tolerant communities. It is most effective only in dense stands with sufficient dry fuel on the ground. Burning is found to be effective on trees larger than three to four inches diameter at breast height (dbh) without any incidence of resprouting. Trees smaller than three to four inches dbh have been observed to re-sprout from the lower stump and root area (Elfers 1998).

3.2.3.3 Biological Control - Insects/Pathogens

No biological control of Australian pine has been approved in the United States. There has been a high rate of root rot in Florida Australian pine caused by the fungus *Clitocybe tabescens*. This has occurred primarily on higher, well-drained, light sandy soils where oak and other hardwood trees were predominant before clearing activities. Root diseases have also been caused by *Pseudomonas solanacearum*, *Trichosporium vesiculorum,* and *Rhizoctonia* spp. Pests that attack the Australian pine include crickets and grasshoppers (*Chondracis rosea, Schistocera gregaria*), defoliators (*Lymantria xylina*), stem borers (*Apate momachus*), and sap feeders (*Icerya* spp.).

3.2.3.4 Biological Control - Grazing

Australian pine is not a candidate for this type of control measure.

3.2.3.5 Herbicide Control

Applying a systemic type herbicide to bark, cut stumps, or foliage appears to be the most effective management tool for heavy infestations of Australian pine. A mixture of isopropylamine salt of imazapyr (e.g., Arsenal®) and glyphosate (e.g., Roundup® Pro) can also be sprayed using the basal bark method. These herbicides are both preapproved for use on North American Air Force bases (DOD 2004). Four to six pints of Arsenal® and two to five quarts of Roundup® Pro should be used per acre. Application should occur after full leaf expansion, and seven or more days should elapse before removal of the plants. Supplemental isopropylamine salt of imazapyr instructions for Florida should be adhered to when using this herbicide. Imazapyr is highly active in soil and has a potential for leaching into groundwater; it should only be used when groundwater impacts can be eliminated or minimized.

Tebuthiuron (e.g., Spike™ 80DF) will also control Australian pine as a spot application at 7½ pounds per acre. Caution needs to be taken when applying tebuthiuron because even a small amount will kill desirable plants if it comes in contact with the roots, which may extend far beyond the dripline. Tebuthiuron is preapproved for use on North American Air Force Bases (DOD 2004).

3.3 Cogon grass (*Imperata cylindrica*)

Cogon grass was identified on CCAFS, roughly four small areas at PAFB, approximately eight small patches at MTA, and a small patch at JDMTA. Most often the populations identified at CCAFS were found as dense patches along roads and other disturbed sites. The patches at MTA are dispersed with the majority being on the west side of the annex. Cogon grass on PAFB is found along the southwest side of the airfield and behind the firing range with some within the closed landfill behind the range as well. The small patch at JDMTA was located southwest of the west side of the parking lot. Cogon grass is listed as a Category I invasive exotic species by the FLEPPC. According to the protocol in the *Handbook for Ranking Exotic Plants for Management and Control*, the significance of impact for cogon grass is high and this species is hard to control (Hiebert and Stubbendieck 1993).

3.3.1 Identification

Cogon grass belongs to the Poaceae/Gramineae family (grass family). Other common names include Japanese blood grass, satintail, and blady grass. Cogon grass is a bright, chartreuse green, perennial grass that grows 2 to 4 feet tall and forms dense stands, excluding other plant species (Photo 7). The leaf blades are erect, about 0.5 inches wide, and have a prominent whitish off-center

midrib and a sharp tip. The leaves are flat with saw-like edges lined with sharp microscopic silica crystals. The round leaf bases are sheathed and attached to short round stems. The upper part of the leaf blade is hairy near the base with a smooth underside. As the plants go dormant, the leaves turn brownish-gray from the tips downward. The dead leaves remain standing and resist decay. Cogon grass roots are sharp pointed, white barbwire-like rhizomes. The roots branch readily, aggressively shooting out from one plant to form another, sometimes piercing the roots of intervening plants. Most of these rhizomes are interwoven in a dense mat within about a foot of the soil surface, but may reach as deep as 3-6 feet. Cogon grass flowers are borne in conspicuous cylindrical silky white spikes 1-16 inches long and 0.25-1 inches in diameter (Photo 8). Each individual flower spikelet has two stamens and two feathery stigmas attached to a fuzzy plume. This plume assists the wind-dispersed seed in drifting through the air. In temperate areas cogon grass usually flowers from late winter through May or in the fall after the first frost but in more tropical areas it may flower year-round (MacDonald et al. 2001; Langeland and Craddock Burks 1998).

3.3.2 Origin and Distribution

Cogon grass originated in Southeast Asia in the Philippines, China, and Japan. It is found on every continent, although it does not tolerate cool temperatures, and is now distributed throughout the tropical and subtropical regions of the world. Over the past 50 years, cogon grass has become widely established in the southeastern United States extending as far north as South Carolina and west to Texas.

Cogon grass first appeared in the United States around Grand Bay, Alabama, escaping from Satsuma orange crate packing in 1912. In 1921, it was intentionally introduced from the Philippines into Mississippi as possible forage. Cogon grass was introduced into Florida in the 1930s and 1940s as forage and for soil stabilization. It has little economic (forage) benefit and has become a serious pest. Consequently, it is on the noxious weed list, which prohibits new plantings of this species. Unfortunately, cogon grass has spread by illegal plantings, inadvertent transport in forage, in soil during roadway construction, and by lawn mowers during roadside maintenance. It is now found throughout Florida from the panhandle region into south Florida (Johnson and Schilling 2004).

Cogon grass usually occurs on highly leached acid soils with low fertility and minimal organic content. It invades a wide variety of habitats including swamps, floodplains, dry scrubs, and sand dunes. It is most commonly found in disturbed areas such as sand hills, roadsides, pastures, utility rights-of-way, and mined lands. Alabama, Mississippi, and Florida have extensive acreage of roadway and pasture infested with cogon grass. In Florida, cogon grass also infests ditch banks, golf courses, and forests. In central Florida, monocultures of cogon grass have become established on hundreds of acres of reclaimed phosphate mining areas. It does not survive in cultivated areas.

Cogon grass is capable of converting vast acreages of biologically diverse landscape into monocultures of low quality grasslands. Its aggressive rhizomatous roots, secretions of allelopathic toxins, and the ability to smother surrounding vegetation with a dense thatch allow it to choke out competition. Cogon grass displaces native plants and reduces faunal diversity.

Photo 7. Cogon grass.

Photo 8. Cogon grass flowers.

3.3.3 Management Considerations and Options

Cogon grass ranks as one of the 10 most undesired weeds in the world. It is an extremely aggressive species that will invade healthy natural communities, established pastures, and disturbed sites. It is illegal to transport cogon grass into or within the U.S. and several states, including Florida, have laws forbidding growing or selling the plant.

Currently, there is no single treatment that effectively eliminates cogon grass infestations. This species will not persist in areas that are frequently cultivated, so frequent tillage can be used for control in certain sites. Mowing or burning will remove above-ground vegetation, but opens the plant canopy for emergence of seedlings and new stems from rhizomes.

Pathogens have been isolated but none have been developed for effective control. Cogon grass does not tolerate dense shade; it dies back upon canopy formation in rubber tree plantations in India. In Florida, reports of invasion into old growth forests suggest that a more shade-tolerant ecotype has developed.

Extensive research has been conducted in Africa, Southeast Asia, and the U.S. for the control of cogon grass. Burning, cultivation, cover crops, and herbicides have been used with varying degrees of effectiveness. To eliminate cogon grass, the rhizomes must be destroyed to avoid regrowth. Cultivation and herbicides have been the two control strategies used most often. Although tillage and herbicides will provide some control and suppression of the grass, long-term eradication is seldom achieved. It has been shown that an integrated approach that combines burning, tillage (mechanical disturbance), and herbicide applications provide the best solution for cogon grass management. Selective herbicide choices are limited and research is continuing in this area.

3.3.3.1 Physical Control – Manual/Mechanical Methods

Cultivation and herbicide use have been the two control strategies used with the best results. One of the oldest and most successful methods is to deep plow or disk several times during the dry season, desiccating the rhizomes and exhausting the food reserves. Cutting to a depth of at least 6 inches ensures that most, if not all the rhizomes have been cut. The success of this method of control can be seen where cogon grass grows up to the edge of a cultivated field without spreading into the field itself. Repeated cultivation is needed to totally desiccate the rhizomes and exhaust food reserves, or a follow-up herbicide application can be used to kill off any individuals that resprout.

An integrated approach for successful, long term cogon grass management includes herbicide use and mechanical and cultural methods. Effective management has been achieved by the following combined mechanical-herbicide protocol. First, the infested area is mowed or burned in late spring/early summer to remove last year's growth and accumulated thatch layer. About six to eight weeks later, when about eighty percent of the cogon grass has re-sprouted to a height of 6 to 12 inches, the site needs to be disked as deeply as possible. Disking may not be possible in all areas, due to the sensitive nature of some ecosystems. When adequate regrowth of the cogon grass has occurred, systemic herbicides should be applied.

3.3.3.2 Physical Control – Prescribed Burning

When cogon grass invades a new habitat, it increases fire frequency, intensity, and flame height, drastically magnifying fire hazards. Cogon grass is extremely fire tolerant and can resprout vigorously following burning. It is taller than many native grasses in fire driven ecosystems, such as longleaf pine forests, and large infestations may cause more frequent and more intense fires than the native grasses in those systems.

Burning can be included as part of an integrated management approach. Initially, cogon grass should be burned or mowed to remove excess thatch and older leaves. This initiates regrowth from the rhizomes, thereby reducing rhizome biomass. It also allows herbicides to be applied to only actively growing leaves, maximizing herbicide absorption into the plant. Ideally, burning should take place in the summer. A one-to-four month regrowth period has been shown to provide a sufficient level of leaf biomass for herbicide treatment. Herbicide applications should be made in the late summer/early fall.

The herbicides glyphosate (e.g., Roundup) or imazapyr (e.g., Arsenal, Chopper) have been shown to provide control. If tillage can be incorporated, using a disking treatment directly following a burn is the best approach. This further depletes the rhizome reserve through desiccation and increases the number of shoots per given area. A one-to-four month regrowth period is recommended before herbicide treatment.

3.3.3.3 Biological Control – Insects/Pathogens

No releases have been made of any natural enemies to cogon grass. There is a general absence of attempted, and thus of successful, biological control projects against grasses. Existence of closely related grasses of economic or ecologic value challenge the variety of insect controls studied. There is little information on the pathogens of cogon grass and their potential as biological control agents, even though pathogens often exhibit specific host associations.

It is possible that fungi associated with cogon grass are more diverse and abundant than indicated by herbarium records. Twelve pathogenic fungi have been identified on cogon grass in Alabama. From 1994 to 1997, field surveys looking for diseased cogon grass or related grasses in Florida collected 70 fungal isolates.

The only insect enemy of cogon grass that has been subjected to host range testing is the gall midge (*Orseolia javanica*). The gall midge was studied on corn, sorghum, five species of rice, and two other grasses, and found to be specific to cogon grass. However, the gall midge is known to be highly parasitized, which limits their potential effectiveness (Van Loan et al. 2002).

3.3.3.4 Biological Control – Grazing

Cogon grass has been utilized in Southeast Asia as forage since it is the dominant vegetation on over 300 million acres. Only very young shoots should be grazed or cut for hay when the leaves lack the sharp points and razor-like leaf margins that make the grass unpalatable to grazers. Crude protein rarely attains the minimal seven percent level necessary to sustain cattle. The low nitrogen, phosphorus, and energy content of cogon grass makes supplementation essential for livestock. The

grass was intentionally introduced from the Philippines into Mississippi as possible forage and was introduced into Florida in the 1930s and 1940s as forage and for soil stabilization. Cogon grass had little forage value and became a serious pest and was consequently placed on the noxious weed list. Grazing is not a recommended control for cogon grass.

3.3.3.5 Herbicide Control

The use of herbicides for control of cogon grass began in the 1940s. Only a few of the hundreds of herbicides tested are effective, and research is continuing in this area (MacDonald et al. 2001). In non-crop areas such as rights-of-way and fencerows, soil sterilants such as prometon (e.g., Pramitol 25E®), and isopropylamine salt of imazapyr (e.g., Arsenal®) will give excellent control. Areas treated with these materials will be free of any vegetation for 6 months to a year, which can promote erosion. Repeated applications each year for several years are needed for control (MacDonald et al. 2001).

In other areas, only limited herbicide control alternatives are available. The best time to apply herbicides is in the early fall before first frost. The herbicides glyphosate (e.g., Roundup® Pro or Rodeo®) or isopropylamine salt of imazapyr (e.g., Arsenal®) have been shown to provide the best control. A 2 percent solution of glyphosate applied at 3 to 4 quarts per acre will substantially reduce cogon grass stands, but several applications are necessary. Glyphosate is a non-selective herbicide and will affect all vegetation in the treatment area. Glyphosate has little or no residual soil activity. If high rates (i.e., 4 to 5 quarts per acre) of glyphosate are used, slight residual may exist in Florida soils. A 10 to 14 day waiting period should be observed before revegetating with tender seeds or seedlings.

In areas where immediate revegetation is not planned and non-target plant damage is not a concern, an application of a 1 to 1½ percent solution of isopropylamine salt of imazapyr (e.g., Arsenal®) at a rate of 1 pint per acre may be used. Follow isopropylamine salt of imazapyr Florida supplemental label information. Because imazapyr is highly active in soil, it has a high potential for leaching into groundwater, and should only be used when groundwater impacts can be eliminated or minimized. Since imazapyr remains in the soil for long periods, its effectiveness on cogon grass and other plants may continue up to a year after application.

All of the herbicides mentioned above are on the list of herbicides approved for use on North American Air Force bases (DOD 2004). Fluazifop (e.g., Fusilade® DX) is registered for use in Florida but is not preapproved for use on North American Air Force bases (DOD 2004), but provides moderate suppression of cogon grass. Fluazifop is a selective grass herbicide that provides more flexibility when desirable broadleaf species are present for revegetation (MacDonald et al. 2001).

The best approach to controlling cogon grass is an integrated approach starting with burning or mowing infestations in the early summer to remove excess thatch and older leaves. This initiates regrowth from the rhizomes, thereby reducing rhizome biomass. It also allows herbicides to be applied to only actively growing leaves, maximizing herbicide absorption into the plant. Ideally, burning should take place in the summer. A one to four month regrowth period has been shown to provide a sufficient level of leaf biomass for herbicide treatment. Isopropylamine salt of imazapyr or glyphosate applications should be made in the late summer or early fall approximately one month prior to the average killing frost.

Till the site a few weeks later and plant a competitive imazapyr-resistant cover crop such as hairy indigo (*Indigofera hirsuta*). Once good control of cogon grass has been achieved, it is essential to introduce desirable vegetation as quickly as possible to prevent cogon grass from re-infesting the area. Several species have been shown to colonize rapidly and tolerate the residual effects of isopropylamine salt of imazapyr. A wider range of plant species can be planted if glyphosate is used due to the lack of soil activity. Cogon grass will eventually begin to re-infest, regardless of control.

Diligence and persistence are essential to control re-infested areas before cogon grass re-establishes. If tillage can be incorporated, using a disking treatment directly following a burn is the best approach. This further depletes the rhizome reserve through desiccation and increases the number of shoots per given area. A one-to-four month regrowth period is recommended before herbicide treatment.

3.4 Torpedo Grass (*Panicum repens*)

Torpedo grass was found at CCAFS, PAFB and MTA along ditches and other wetland and riparian habitats. Torpedo grass is listed as a Category I invasive exotic species by the FLEPPC. According to the protocol in the *Handbook for Ranking Exotic Plants for Management and Control*, the significance of impact for torpedo grass is moderate and this species is identified as being hard to control (Hiebert and Stubbendieck 1993).

Photo 9. Torpedo grass (Hitchcock 1950).

3.4.1 Identification

Torpedo grass is a member of the Poaceae/Gramineae family (grass family). Other common names include quack grass and bullet grass. Torpedo grass is a perennial grass that frequently forms dense colonies with long, creeping, pointed rhizomes (Photo 9). Flowering stems are erect and up to 2.6-feet tall. The lower stems sometimes lack leaf blades and consist of only sheaths. Leaves of the upper stem have both sheaths and blades. The blades are relatively short, flat or sometimes folded, from 0.08-0.2-inches wide. The inflorescence is a loose, open panicle that is 1.2 to 3.9-inches long with weakly divergent to ascending branches. Spikelets are about 0.1-inch long. Species in the genus *Panicum* are difficult to identify so positive identification requires someone with considerable experience in identifying grasses (Langeland and Stocker 2000).

3.4.2 Origin and Distribution

Torpedo grass is a widespread tropical or subtropical grass that may have been introduced into the U.S. The genus *Panicum* has the greatest number of species in the grass family, with as many as 600 species worldwide and about 170 species found in the U.S.

Torpedo grass grows in moist, often sandy soil along beaches and dunes, margins of lagoons, marshy shorelines of lakes and ponds, drainage ditches, and canals. Its rhizomes can extend several feet out into the water, forming dense floating mats. These mats may impede water flow in ditches and canals and restrict recreational use of shoreline areas of lakes and ponds.

The invasiveness of this species causes the loss of wetland habitat for waterfowl and fur bearing animals. Torpedo grass forms a dense vertical wall along infested shorelines that wildlife cannot penetrate. These dense mats interfere with nesting by many species of ducks that would normally use native wetland plant communities in these locations.

3.4.3 Management Considerations and Options

The following management considerations and options were proposed by the United States Army Corps of Engineers (USACE), Engineer Research and Development Center, Waterways Experiment Station, Vicksburg, MS in the *Noxious and Nuisance Plant Management Information System*, unless otherwise referenced (USACE 2004).

3.4.3.1 Physical Control – Manual/Mechanical Methods

The following are types of mechanical control methods that have been used with success for the management of torpedo grass. The cookie cutter, flail chopper, hand removal, and harvest methods are discussed below.

The cookie cutter is a barge/cutting system developed in Florida to manage emergent aquatic vegetation, floating islands of vegetation, and sediment. It can cut openings in shoreline and wetland areas through emergent wetland plants and invasive aquatic plant species. It is one system that can cut channels into the weed mass and open up areas for nesting and bird access.

The system will clear all vegetation that it contacts. It can also create channels up to 3 feet deep in shoreline hydric soils. Plant biomass may need to be collected since cookie cutter reduces vegetation to small fragments. An aquatic plant harvester working with the cookie cutter can mitigate this problem in some circumstances. Many invasive aquatic plants will eventually recolonize these areas if no other control methodology is implemented for the site.

Flail choppers can be effective on invasive plants in a variety of aquatic and wetland sites. Flail choppers will provide excellent short-term clearing of herbaceous plants and young invasive woody plants, but if invasive species are woody and established this method is not recommended. Flail choppers are attachments to either land- or water-based mechanical control systems. The device can be mounted on an extending arm from a water-based system, like an Aquamog®. A flail chopper has a number of knife blades that rotate rapidly inside a hood. The operator then directs the knife blades to cut the vegetation. This system will chop all plants that contact the blade. Access from either the shoreline or the landside is limited to the equipment that carries and powers the flail chopper.

As with other mechanical chopping procedures, plant biomass may need to be collected. Since flail choppers reduce vegetation to small fragments, this biomass could cause problems if it travels downstream and collects on structures like dams or bridges. Fragments can resprout and spread the plant to new locations, exacerbating the problem.

Hand removal is another physical control for torpedo grass. Terrestrial invasive plant species can be removed from small areas by pulling or cutting the vegetation with hand tools. In many regions, this must be done more than once in a growing season. The best time for hand removal of torpedo grass is after seedhead production but before flowering. Pulling the roots is not generally recommended since it may stimulate new shoot production. Hand removal operations have the expense of the removal equipment as well as labor costs. If the ground in the removal site is disturbed, reseeding should be considered. The efficiency of the hand removal operation depends on the compatibility of the chosen equipment and labor with the site to be controlled.

Harvesting can be used to control torpedo grass. The plant harvester travels on the water to the target area and collects the vegetation. Either the harvester or a transport vessel can be used to move the cut material to a disposal site. Most harvesters have shore conveyor or trailer conveyor systems that allow the cut vegetation to be unloaded and transported to an upland disposal site. Most aquatic plant harvesting systems will cut and remove submersed plants to a depth of 5 to 7 feet. As this biomass is removed from the lake, the water is ready to use at once and there are no restrictions on use of the area that might be experienced with an herbicide or some biological control

treatments. Harvesting system performance is in the 1 to 3 acre per day range, depending on the equipment mix and the shoreline access. The USACE Aquatic Plant Control Research Program has developed a predictive model that allows the user to evaluate different mixes of equipment against the parameters that impact performance of harvesting systems and develop cost and time analyses. Copies of the model are found on the Aquatic Plant Information System website (2004).

3.4.3.2 Physical Control – Prescribed Burning

Prescribed fire can kill the herbaceous tops of torpedo grass; however, rhizomes below the soil surface typically survive. Therefore, sprouting and spread are likely following a prescribed fire. However, sprouting plants may be more susceptible to herbicide application (see section 3.4.1.4) as a result of better contact and penetration through immature young shoots (Stone 2011).

3.4.3.3 Biological Control – Insects/Pathogens

There are currently no insects or pathogens being used for control of torpedo grass.

3.4.3.4 Herbicide Control

Torpedo grass is a perennial that has numerous dormant buds associated with extensive rhizomes that make this plant extremely difficult to control. Several years of re-application of herbicides may be necessary for complete eradication.

A glyphosate product for aquatic environments (e.g., Rodeo®, Aquamaster™) at a rate of 6 to 7½ pints per acre plus 2 or more quarts of a nonionic surfactant will partially control torpedo grass. Use the lower rates for terrestrial sites and the higher rates for partially submerged or floating mats of vegetation. Apply when plants are actively growing and most have reached early head or early bud stage. Allow at least 7 days before removing vegetation. Re-apply as necessary when plants regrow up to 4 to 6-inches tall.

A 0.5 percent solution of isopropylamine salt of imazapyr (e.g., Arsenal®)as a spot treatment or broadcast at 3 to 4 pints per acre is will also provide partial control. Follow Arsenal® Florida supplemental label instructions. Because imazapyr is highly active in soil, it has a high potential for leaching into groundwater, and should only be used when groundwater impacts can be eliminated or minimized. Since imazapyr remains in the soil for long periods, its effectiveness may continue up to a year after application.

Torpedo grass is susceptible to pre-emergence, and post-emergence applications of bromacil (e.g., Hyvar® X-L or Hyvar® X) or bromacil-diuron (e.g., Krovar® I DF) if coverage is adequate coverage. Two and three applications may be necessary for complete eradication. Torpedograss is tolerant of diuron (Diuron 80DF IVM) no matter how it is applied. Bromacil is banned in some Florida counties but non-agricultural usage is allowed in Brevard County at rates not to exceed 8 pounds per acre (6.4 pounds of active ingredient) per year, inclusive of all bromacil formulations including bromacil-diuron. Do not use near freshwater or saltwater habitats including marshes, ditches, banks of waterways, bogs, creeks, bays, estuaries, and reservoirs, to impervious substrates, or to areas where the roots of desirable vegetation may extend. Due to these restrictions, bromacil is not recommended for Cape Canaveral.

3.5 Melaleuca (*Melaleuca quinquenervia*)

Melaleuca was found on CCAFS and PAFB in a developed area around buildings and the PAFB Golf Course planted as ornamentals, as well as at MTA and JDMTA. Melaleuca is listed as a Category I invasive exotic species by the FLEPPC. This species is a federal and state listed noxious species and is a prohibited Class 1 aquatic plant (USDA NRCS 2003). According to the protocol in the *Handbook for Ranking Exotic Plants for Management and Control*, the significance of impact for melaleuca is high and this species is identified as being moderate to hard to control (Hiebert and

Stubbendieck 1993). However, because it is not found in high densities on CCAFS, controlling it will be relatively simple. Therefore, removal of this species is warranted. The sections below discuss a number of different methods for controlling melaleuca. Since the densities of melaleuca are low on CCAFS, simple mechanical or herbicide controls will provide adequate control of this species.

3.5.1 Identification

Melaleuca is a member of the Myrtaceae family (myrtle family). Other common names include cajeput tree, punk-tree, paper-bark tree, five-veined paperbark, and white bottle-brush tree. Melaleuca trees grow to approximately 80 feet tall. Its bark is whitish, spongy, peeling, and in many layers. Its leaves are to five inches long, alternate, evergreen, simple, short-stalked, narrowly elliptic. Leaf veins are more or less parallel. Melaleuca's white flowers are small and crowded in bottlebrush-like spikes at branch tips. The fruit are short, cylindric or squarish, woody capsules with many tiny seeds (IFAS 2004). Individual trees bloom from two to five times a year.

3.5.2 Origin and Distribution

Melaleuca's native range is along the coast of eastern Australia from Sydney northward. It is also native in New Caledonia, Papua New Guinea, and Irian Jaya. In the continental U.S., melaleuca has naturalized in southern Florida. The largest concentrations are in Palm Beach, Broward, Dade, Collier, and Glades Counties. A million trees have been planted in Hawaii with natural regeneration limited to the island of Maui. Planted melaleuca can also be found in parts of southern California and southern Texas.

Originally planted as an ornamental, melaleuca has spread throughout south Florida. Numerous introductions in various parts of the peninsula include the Everglades and the Big Cypress Swamp. The first establishment occurred when seedlings were planted along Biscayne Bay in 1906. Subsequent introductions occurred in 1912 on the west coast of Florida near the Big Cypress Swamp; in 1936 when collected seeds were aerially broadcast over the eastern Everglades; and in 1941 when trees were planted on levees around Lake Okeechobee for soil stabilization. The intent of this rather intensive series of introductions was to dry out south Florida's wetlands and to create a timber resource. It was also thought that "draining the swamp" would enhance development.

Melaleuca tolerates a broad range of site conditions. It becomes established more readily on sand than on marl but can survive on almost any soil in south Florida. It tolerates extended flooding, moderate drought, and some salinity. Melaleuca rarely has to compete directly with other tree species in Florida. It typically invades sparsely vegetated areas, prairies, marshes, and fire-damaged forests. Massive seed release follows disturbance such as fire. This allows melaleuca to invade the site and form an almost pure stand. Pure stands with a closed canopy will inhibit the development of understory vegetation, including melaleuca seedlings.

3.5.3 Management Considerations and Options

About three years after germination, melaleuca begins to produce and store copious numbers of seeds in closed woody capsules. The seeds are stored until some form of stress, such as frost, fire, or human- induced injury causes the capsules to open. A mature tree can produce more than a million seeds per year and store an estimated 20 million. Viable seeds have been found in capsules that are 15 years old, but seed viability declines with age. Most capsules do not open until the conductive tissue connecting them to the tree is disrupted by shoot growth and bark production, or by stress, such as fire, frost, mechanical damage, or herbicide treatment. Following stress, a massive seed release can begin within a few hours and continue over several days. Melaleuca has no adaptations that aid in seed dispersal, however, seeds may be dispersed by birds and other wildlife species. The seeds will also float on water if the surface tension is maintained. The seeds are long-lived, remaining viable up to 10 months, and up to 6 months when submerged in water.

Melaleuca stumps sprout readily and generate adventitious buds on its roots and shoots. This results in coppicing below a cut or when the apical bud is destroyed. Broken branches that fall on suitable soils may root and grow. The adventitious buds generate a collar of "water roots" in the water column above the sediment where there is prolonged flooding. Melaleuca causes respiratory irritation, headache, and nausea to some people and contact with the bark can cause a skin rash.

3.5.3.1 Physical Control – Manual/Mechanical Methods

Due to the sensitivity of many of the infested areas in south Florida, the large-scale removal of melaleuca by mechanical means is not a viable option because of potential disturbance to soils and non-target vegetation. Removal using heavy equipment is an acceptable control along canals, utility rights-of-way, and other similar areas adjacent to infested wetlands. The only methods of mechanical control currently being utilized are the felling of trees in place and the manual removal of seedlings that are less than 7-feet tall. This is highly labor intensive and is feasible only in small areas.

3.5.3.2 Physical Control – Prescribed Burning

Burning is not a satisfactory control option for a number of reasons. Melaleuca has a protective layer of moisture filled bark that provides significant protection to the vascular cambium. Adult trees are fire resistant; the paper-like outer bark burns quickly and sends the fire into the canopy igniting the oil-laden foliage. The leaves and small branches are killed, but dormant lateral buds on the trunk germinate within weeks after the burn.

Hot surface fires typically kill seedlings that are less than 3 to 6 months old, or only 4 to 8-inches tall. Death may occur as a result of lethal temperatures, insufficient food reserves to produce new shoots, or drying of the sediments due to increased exposure. Older seedlings are top-killed by most fires but recover quickly, often with multiple shoots sprouting from the root collar.

Stresses such as fire catalyze seed release from the capsules. The fertile ash bed and more open canopy that result from a fire provide optimal conditions for seed germination and seedling establishment. Burning is a potential control agent on small saplings that do not yet have a thick layer of protective bark. There are many concerns associated with prescribed burns including effects on non-target vegetation, seed release by seed trees, and liability issues. If prescribed burns are implemented, they should be done at the end of the wet season so that the seeds attempt to germinate and establish during the dry season when conditions are not optimal. Periodic rains throughout the dry season may be enough to ensure seed survive until the following wet season.

Fire alone has not been recommended as an effective means of controlling melaleuca. If the adult melaleuca were killed by below-freezing temperatures, burning might eliminate any subsequent seedlings. Another use of fire would be to induce a seed release at a time when germinating seeds would be killed by drought or flooding. This method would require accurate predictions of water level changes and needs additional research.

3.5.3.3 Biological Control – Insects/Pathogens

Melaleuca thrives in its adopted range due to a lack of natural competition in the form of insect herbivores and disease. Biological control may offer some help in management of melaleuca by bringing natural enemies of the species from its native range in Australia to its new range in Florida. Most likely, no single insect will provide effective control by itself. A variety of species will be necessary to reduce the reproductive potential of melaleuca (UF 2004).

Surveys for potential biological control agents in Australia have uncovered over 400 species of insects that feed on melaleuca. The few species that have been either approved for or have been studied further for release in Florida include:

- *Oxyops vitiosa* - a foliage-feeding weevil
- *Lophyrotoma zonalis* - a defoliating sawfly
- *Boreioglycaspis melaleucae* - a psyllid
- *Eucerocoris suspectus* - a leaf-blotching bug
- *Pomponatius typicus* - a coreid bug
- *Fergusonina turneri*/*Fergusobia quinquenerviae* - bud-gall fly and obligate nematode
- *Poliopaschia lithochlora* - pyrilid moth.

However, because the melaleuca trees that occur on the stations were planted as ornamentals and are primarily being controlled by routine lawn maintenance, the use of insects or pathogens is not a feasible control method.

3.5.3.4 Herbicide Control

Herbicides are usually needed for extensive infestations of mature melaleuca trees and may be applied to freshly cut stumps or to girdled trunks. Every tree trunk must be completely treated and re-treated. Many of the effective herbicides are restricted to areas without surface water and many native species are sensitive to the herbicides.

Herbicide control of melaleuca in parts of Florida is a vital part of eradication efforts, but must be done carefully. Herbicide application during January and February will maximize efficiency, since melaleuca exhibits a flush of growth at this time. One commonly used method is the frill or girdle (hack-and-squirt) method, which entails girdling the circumference of mature trees and applying herbicide directly to the tree's cambium. Another herbicide method is the cut-stump strategy, where the herbicide is applied to the stump of a cut tree to prevent coppicing. Using either of these methods reduces effects on non-target vegetation since treatment is applied one tree at a time. However, these techniques are labor intensive, extremely costly, and slow in terms of the area treated. A stressful event such as girdling and herbicide application will cause the tree to release millions of seeds from their capsules, so follow-up treatment within two years of the initial treatment is recommended. Doing the second application in that time frame ensures that the resulting seedlings are eliminated before they can produce viable seeds. The cut-stump method should typically be used on small trees (less than 2 inches in diameter) due to the navigation hazards.

Isopropylamine salt of imazapyr (e.g., Arsenal®) in a 50 percent solution or 4 to 6 pints per acre has proven to be most consistently effective when using the frill/girdle or cut-stump methods of application, according to the FLEPPC. Follow Florida supplemental label information. Because imazapyr is highly active in soil, it has a high potential for leaching into groundwater, and should only be used when groundwater impacts can be eliminated or minimized. Since imazapyr remains in the soil for long periods, its effectiveness may continue up to a year after application.

3.6 Mimosa (*Albizia julibrissin*)

Mimosa is found at CCAFS on and around the Trident and Poseidon spoil areas within the southern extents of CCAFS. PAFB's back dune area has been treated for roughly 20 small seedling to sapling size specimens of mimosa. Two individual mimosa trees were identified at MTA. Mimosa is listed as a Category I invasive exotic species by the FLEPPC. According to the protocol in the *Handbook for Ranking Exotic Plants for Management and Control* the significance of impact for mimosa is low and this species was identified as being easy to control (Hiebert and Stubbendieck 1993).

3.6.1 Identification

Mimosa is a member of the Fabaceae/Leguminosae (Mimosoideae) family, the pea family. It is a small to medium-sized tree that can grow up to 20-40 feet tall. The light brown bark is nearly smooth, and generally thin with lens shaped areas along the stem. The attractive fern-like leaves are finely divided, 5-8 inches long by about 3-4 inches wide, and alternate along the stems. Each bipinnate leaf is made up of hundreds of tiny leaflets coated in white hairs, giving the foliage a silvery cast. Mimosa has showy and fragrant pink flowers, about 1½ inches long, that resemble pom-poms (Photo 10). They are arranged in panicles at the ends of branches. Fruits are flat, straw-colored pods about 6 inches long containing light brown oval-shaped seeds about ½ inch in length. The pods ripen in August to September and remain on the trees into winter (Remaley 1998).

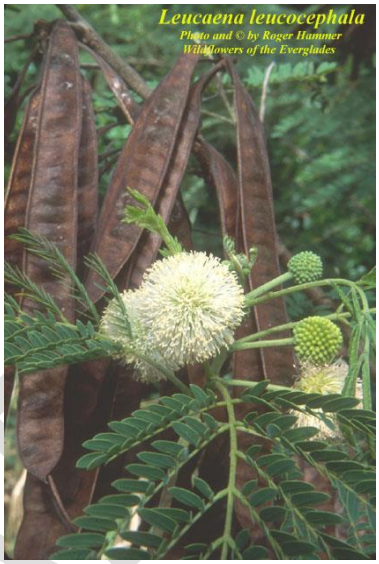

Photo 10. Mimosa flower.

3.6.2 Origin and Distribution

Mimosa's native range is from Iran to Japan. Mimosa was introduced to the United States in 1745 and is naturalized from New Jersey to Louisiana and in California. Mimosa is still planted as an ornamental because of its fragrant and showy flowers.

Mimosa takes advantage of disturbed areas and may spread by seed from nearby ornamentals or from contaminated fill dirt. It prefers full sun and is often seen along roadsides and open vacant lots in urban/suburban areas. Mimosa is tolerant of partial shade but is seldom found in forests with full canopy cover, or at higher elevations (above 3,000 feet). It can become a problem along riparian areas, because its seeds can be easily transported in water. It is capable of growing in a wide range of soil conditions (Remaley 1998).

3.6.3 Management Considerations and Options

Mimosa reproduces both vegetatively and by seed. Seeds of this species have impermeable seed coats that allow them to remain dormant for many years (from 5 to 50 years depending on the species). Seeds are mostly dispersed below or around the parent plant, but can be dispersed further by water.

Mimosa can grow in a variety of soils, produce large seed crops, and resprout when damaged making it is a strong competitor to native trees and shrubs in open areas or forest edges. Mimosa grow rapidly under good conditions but are short-lived and have weak, brittle wood. If cut or top-killed, trees resprout quickly and sprouts can grow over three feet in a season. Dense stands of mimosa severely reduce the sunlight and nutrients available for other plants (Remaley 1998). Mimosa tree can be controlled using a variety of mechanical and chemical controls.

3.6.3.1 Physical Control – Manual/Mechanical Methods

Mimosa trees can be cut at ground level with power or manual saws. This is most effective when trees have begun to flower preventing seed production. Mimosa spreads by suckering so resprouts are common after treatment. Cutting is an initial control method that needs to be followed with either an herbicide application or repeated cutting for resprouts (Remaley 1998).

Girdling is effective on large trees. Use a hatchet to make a cut through the bark encircling the base of the tree, approximately six inches above the ground. A follow-up treatment with a foliar herbicide may be required to control resprouts. Hand pulling will effectively control young seedlings. Pull plants

as soon as they are large enough to grasp, but before they are old enough to flower. The entire root must be removed since broken fragments may resprout (Remaley 1998).

3.6.3.2 Physical Control – Prescribed Burning

Because of the small number of these trees at CCAFS, PAFB, and MTA, prescribed burning is not a recommended control.

3.6.3.3 Biological Control – Grazing

Because of the small number of these trees at CCAFS, PAFB, and MTA, grazing is not a recommended control.

3.6.3.4 Biological Control – Insects/Pathogens

Because of the small number of these trees at CCAFS, PAFB, and MTA, biological control is not a recommended control.

3.6.3.5 Herbicide Control

Mimosa seedlings and small trees can be controlled by applying a 2 percent solution of glyphosate (e.g., Roundup®) or triclopyr (e.g., Garlon®) plus a 0.5 percent non-ionic surfactant, thoroughly wetting all leaves. These herbicides can kill entire plants because the glyphosate is a systemic that travels through a plant from the leaves and stems to the actively growing roots, where they prevent further cell growth. Use a low pressure, coarse spray pattern to reduce damage from spray drift on non-target species. Triclopyr is a selective herbicide for many broad-leaved plant species and is best for sites where native or other desirable grasses are meant to be conserved (Remaley 1998). Glyphosate is approved for use on North American Air Force bases; however, triclopyr is not (DOD 2004). The cut-stump and basal bark herbicidal methods should be considered when treating individual trees or where the presence of desirable species preclude foliar application.

3.7 Hydrilla (*Hydrilla verticillata*)

Hydrilla has been positively identified in the PAFB Golf Course canals. It is more than likely found in some of the CCAFS canals but has not been identified yet. Hydrilla is listed as a Category I invasive exotic species by the FLEPPC. According to the protocol in the *Handbook for Ranking Exotic Plants for Management and Control* the significance of impact for hydrilla was high and was identified as being hard to control (Hiebert and Stubbendieck 1993).

3.7.1 Identification

Hydrilla grows very rapidly from rootstocks, subterranean turions, vegetative buds (turions), and vegetative nodes. Only one node (whorl of leaves) is necessary for growth. In clear water the plant can grow in depths of more than 40 feet. When growing from the bottom the leaves may be up to, or more than, 6 inches apart. The leaves on the lower part of the stem may be opposite. As the stem reaches the surface the leaves become whorled and occur much more closely together on the stem. As the stem reaches the surface extensive branching occurs, often forming dense mats. Hydrilla can spread rapidly and will replace native vegetation. Pollination occurs above the surface of the water. The pollen is dispersed aerially and must land dry on the stigma.

Photo 11. Hydrilla

3.7.2 Origin and Distribution

Native to the warmer areas of Asia, hydrilla was first discovered in the United States in 1960. It is a cosmopolitan species that occurs

in Europe, Asia, Australia, New Zealand, the Pacific Islands, Africa, Europe, South America, and North America. Although hydrilla occurs in temperate areas, it tends to be more widespread in tropical areas of the world. A highly specialized growth habit, physiological characteristics, and reproduction make this plant well adapted to life in submersed freshwater environments. Consequently, hydrilla has spread rapidly through portions of the United States and become a serious weed. Where the plant occurs, it causes substantial economic hardships, interferes with various water uses, displaces native aquatic plant communities, and adversely impacts freshwater habitats. transported in water. It is capable of growing in a wide range of soil conditions (Langeland 1996).

3.7.3 Management Considerations and Options

Hydrilla is very efficient at reproducing itself and maintaining itself during adverse conditions. It can reproduce itself in four different ways: fragmentation, tubers, turions, and seed. Almost 50% of hydrilla fragments that have a single whorl of leaves can sprout a new plant that a new population can grow from, and greater than 50% of fragments with only three whorls of leaves can sprout (Langeland and Sutton 1980). This means that small amounts of hydrilla on boat trailers, bait buckets, draglines, and from aquariums can spread the plant from place to place. Turions are formed terminally on rhizomes (commonly called tubers or subterranean turions) and in leaf axils (commonly called turions or axillary turions). One single subterranean turion has been shown to produce over 6,000 new turions per square meter (Sutton *et al.* 1992), and 2,803 axillary turions can potentially be produced per square meter (Thullen 1990). Subterranean turions can remain viable for several days out of water (Basiouny *et al*.1978), and for over four years in undisturbed sediment (Van and Steward 1990). They also survive ingestion and regurgitation by waterfowl (Joyce *et al*. 1980), and herbicide applications (Haller *et al.* 1990). Hydrilla can be controlled using a variety of mechanical and chemical controls, but is a species that is very difficult to eradicate. Biological controls have been developed as well for hydrilla such as grass carp (*Ctenopharyngodon idella* Val.), and some experimental insects.

3.7.3.1 Physical Control – Manual/Mechanical Methods

Mechanical removal is viable but not long-term; as cyclic maintenance and removal is required. Cost for removal is generally $1,000 per acre and because of hydrilla's rapid growth rate, up to six harvests are required annually (McGehee 1979).

3.7.3.2 Biological Control – Grass Carp, etc.

Biological control with grass carp is recommended, but special permits are required and the water system must be contained.

3.7.3.3 Biological Control – Insects/Pathogens

It is unclear at this time what kind of success has been found with this method; therefore it is not currently a recommended control.

3.7.3.4 Herbicide Control

The herbicide active ingredients, copper, diquat, endothall, and fluridone, can be used to selectively control hydrilla to some extent, depending on the associated plant community. Copper, diquat and endothall are fast acting contact herbicides that have relatively broad spectrums on submersed aquatic plants. They are used to selectively control hydrilla by injection of liquid herbicides, from trailing hoses, under floating leafed vegetation such as spadderdock (*Nuphar* sp.) or around emergent vegetation such as bulrush (*Scirpus* sp.) (Langeland *et al.* 1991). Granular endothall can be used in the same manner. Fluridone is only effective for whole-pond applications or large scale (greater than 2 hectare) applications in large water bodies and its selectivity is dependent on application rates, contact times, and timing of applications. For example, fluridone has been used to manage hydrilla in Lake Okeechobee with minimum to no long term impact on a native vegetation

community consisting of southern naiad (*Najas guadalupensis*), eelgrass (*Vallisneria* sp.), pondweed (*Potamogeton illinoensis*), and American lotus (*Nelumbo lutea*) (Langeland *et al.* 1991).

3.8 Earleaf *acacia* (*Acacia auriculiformis*)

Earleaf acacia is found at CCAFS and JDMTA as individual trees in several areas. Earleaf acacia is listed as a Category I invasive exotic species by the FLEPPC. The significance of impact for earleaf acacia is low and this species was identified as being easy to control (Hiebert and Stubbendieck 1993).

3.8.1 Identification

An evergreen, unarmed tree to 15 m (50 ft) tall, with compact spread, often multi-stemmed; young growth glaucous. Leaves alternate, simple, reduced to phyllodes (flattened leaf stalks), these blade-like, slightly curved, 11-20 cm (5-8 in) long, with 3-7 main parallel veins and a marginal gland near the base; surfaces dark green. Flowers in loose, yellow-orange spikes at leaf axils or in clusters of spikes at stem tips; flowers mimosa-like, with numerous free stamens. Fruit a flat, oblong pod, twisted at maturity, splitting to reveal flat black seeds attached by orange, string like arils.

Photo 12. Earleaf acacia, UF Center Aquatic and Invasive Plants.

3.8.2 Origin and Distribution

Introduced to Florida from Australia, Papua New Guinea, and Indonesia for ornamental use in Florida before 1932 (Gordon and Thomas 1997). Earleaf acacia was used extensively in street landscaping in southern Florida for many years. This species has been noted as escaping cultivation by Morton (1976, 1985), Austin (1978), and Isely (1990). In Florida, earleaf acacia is now reported from over 24 natural areas in Dade, Broward, Palm Beach, Martin, Collier, and Lee counties (EPPC 1996). Naturalized populations have been documented by herbarium specimens from Monroe, Dade, Palm Beach, Martin, and Collier counties (Wunderlin *et al.* 1995).

3.8.3 Management Considerations and Options

Earleaf acacia grows in zones with average minimum temperatures of -1.2 to -6.6°C (30 to 20°F) and above (Broschat and Meerow 1991). Particularly drought resistant, it can also tolerate seasonally waterlogged soils. This species can grow in a wide range of soil types and soil pH and is able to withstand competition from cogon grass (see *Imperata cylindrica*) (Boland *et al.*,1991). Earleaf acacia is aided in drought resistance and low-nutrient tolerance by mycorrhizal and nitrogen-fixing bacterial associations of the roots (Osonubi *et al.* 1991, MacDicken and Brewbaker 1989). This species is found in its native range from dune ridges to river banks (Boland *et al.* 1991), and flowers in Florida from spring through fall, fruiting prolifically. Acacia seeds are dispersed by several bird species, including the introduced European starling (D. F. Austin, Florida Atlantic University, 1997 personal communication). Seed germination can be hastened by placing seeds in hot ashes (Bailey and Bailey 1947). Earleaf acacia tree can be controlled using a variety of mechanical and chemical controls.

3.8.3.1 Physical Control – Manual/Mechanical Methods

Earleaf acacia trees can be cut at ground level with power or manual saws. This is most effective when trees have begun to flower preventing seed production. Cutting is an initial control method that needs to be followed with either an herbicide application or repeated cutting for resprouts (Remaley 1998).

Girdling is effective on large trees. Use a hatchet to make a cut through the bark encircling the base of the tree, approximately six inches above the ground. A follow-up treatment with a foliar herbicide may be required to control resprouts. Hand pulling will effectively control young seedlings. Pull plants as soon as they are large enough to grasp, but before they are old enough to flower. The entire root must be removed since broken fragments may resprout (Remaley 1998).

3.8.3.2 Physical Control – Prescribed Burning

Because of the small number of these trees at CCAFS and JDMTA, prescribed burning is not a recommended control. However, burning on adjacent Jonathan Dickinson State Park property should help control specimens found outside of the fence line.

3.8.3.3 Biological Control – Grazing

Because of the small number of these trees at CCAFS and JDMTA and security fencing requirements, grazing is not a recommended control.

3.8.3.4 Biological Control – Insects/Pathogens

Because of the small number of these trees at CCAFS and JDMTA, biological control is not a recommended control.

3.8.3.5 Herbicide Control

The University of Florida Institute of Food and Agricultural Sciences Extension recommends a basal bark application of 10% Garlon 4 or cut-stump treatment with 50% Garlon 3A; addition of 3% Stalker will increase consistency.

3.9 Chaste tree (*Vitex trifolia*)

The chaste tree is found at CCAFS, PAFB, and MTA near the beach and canals at these locations. The chaste tree is listed as a Category II invasive exotic species by the FLEPPC. This species replaces local plants and also disrupts nesting sites for coastal wildlife.

3.9.1 Identification

The chaste tree is a shrub or small tree with gray or brown bark. Its stems are covered by soft hairs, with opposite, compound, green leaves. The underside of the leaves are a grayish green and covered with hairs. Flowers are blue or purple and tube shaped. The chaste tree produces black, small, spherical fruits.

Photo 13. *V. trifolia* shrub.

3.9.2 Origin and Distribution

Chaste tree is a coastal species native to Asia that was introduced to Florida as an ornamental plant around 1940 (FNAI 2014). Observations of chaste tree have been made as far north as Putnam County, but prevalence of the species ranges from Brevard County to the Keys on the east coast, and Hillsborough to Collier County on the west coast.

3.9.3 Management Considerations and Options

Disturbed areas are commonly invaded with chaste tree due to its ability to outcompete native species. As little information regarding management recommendations for chaste tree exists, the following recommendations are for *V. rotundifolia*, which has a similar distribution and poses comparable threats to native species.

3.9.3.1 Physical Control – Manual/Mechanical Methods

Hand pulling or digging small saplings, or the use of machinery for larger shrubs, are suitable options for eradicating chaste tree. The use of these methods depends on the environment where chaste tree is found, for example, machinery may be a poorly suited option in sand dunes and other sensitive coastal areas. Digging or pulling plants by hand can be used in areas not suited for heavy machinery or herbicide application (GRI 2007). The root ball and stem fragments must be entirely removed, and these along with any other plant material should be burned as fragments can reestablish plants (Sea Grant 2006).

3.9.3.2 Physical Control – Prescribed Burning

Prescribed burning is not a recommended control.

3.9.3.3 Biological Control – Grazing

Due to security fencing requirements and other management limitations, grazing is not a recommended control.

3.9.3.4 Biological Control – Insects/Pathogens

Mushroom root rot and mites are frequent problems for chaste tree; however, their impacts are often not significant enough to kill the plant.

3.9.3.5 Herbicide Control

Herbicide is an effective treatment; however, herbicides should be selected carefully and used sparingly if treated populations are in sensitive areas or in close proximity to the ocean (Sea Grant 2006). Additionally, treatments can also damage other broadleaf or grass plants (GRI 2007). Glyphosate can be applied on the exposed area of cut stumps, or applied to wounded stems. Oil based herbicide mixtures can also be applied to the base of the stem in a band (Sea Grant 2006). Table 2 identifies those herbicides recommended for the management of chaste tree.

Table 2. Recommended Herbicides and Application Methods for Management of Chaste Tree.

Herbicide*	Method	Rate
2,4-D+2,4-DP	High volume	1 to 1.5%
	Frill, basal, cut stump	3 to 4% in oil
Escort®	Low volume	1 to 3 oz
	High volume	0.5 to 2 oz
Arsenal®	Low volume or soil	2 to 6 pt/A
Krenite®	Low volume	1.5 to 6 gal/A

(Source: GRI 2007)

*Herbicides listed in this table are labeled to control wild grape and have not been specially tested for the control of *Vitex* spp.

3.10 Common guava (*Psidium guajava)*

Common guava has been observed CCAFA and MTA. Common guava is listed as a Category I invasive exotic species by the FLEPPC.

3.10.1 Identification

Common guava is an evergreen shrub or small tree that grows up to 9 meters tall, with simple, short-stalked leaves (Photo 14). The tree produces small, white, fragrant flowers with many stamens on a year-round basis. Fruit are oval or pear-shaped, and turn yellow at maturity with dark pink flesh.

Photo 14. Common guava, UF Center Aquatic and Invasive Plants.

3.10.2 Origin and Distribution

This species originated in Asia and Australia, and was one of the first species introduced to Florida in 1765 for edible fruit and as an ornamental (Langeland *et al*. 2008). It is native from southern Mexico south to South America; and can now be found from Pinellas and Brevard counties south to the Keys. Common guava can be found in maritime hammocks, coastal berms, coastal strands, shell mounds, scrub, upland glades, upland pine forests, mesic flatwoods, strand swamps, and ruderal communities (Langeland *et al*. 2008).

3.10.3 Management Considerations and Options

Young common guava plans are tolerant of cold to -7˚C if water stressed. Seed dispersal by birds and mammals (such as bats) is problematic as the common guava has high seed production and early seed maturity. Seedlings may flower within two years, and clonally propagated trees can bear fruit during the first year after planting. Common guava is a strong competitor in early secondary growth, can adapt to a wide range of growing conditions, and grows well on poor soils. Root systems can be quite extensive with no recognizable tap root.

3.10.3.1 Physical Control – Manual/Mechanical Methods

Pulling or digging can be a viable method of control for saplings or small plants, as long as the entire root system is removed (Weber 2003). Cut stems will re-shoot, and guavas can sucker from their roots.

3.10.3.2 Physical Control – Prescribed Burning

Due to its ability to regenerate vegetatively from suckers, common guava is able to survive fires.

3.10.3.3 Biological Control – Grazing

Due to security fencing requirements and other management limitations, grazing is not a recommended control.

3.10.3.4 Biological Control – Insects/Pathogens

Biological controls are not recommended as there are direct conflicts with the interest of fruit growers.

3.10.3.5 Herbicide Control

The waxy cuticle of common guava's leaves reduces the effectiveness of herbicide application. Stumps should be treated with an herbicide to prevent regeneration through suckering (Weber 2002). The recommended treatment for cut stumps or basal bark is 10% Garlon 4.

3.11 Old World climbing fern (*Lygodium microphyllum)*

MTA is the only 45 SW installation where Old World climbing fern was observed. Old World climbing fern is listed as a Category I invasive exotic species by the FLEPPC. This species is a serious weed in south and central Florida, where it is increasing in density and range (FLEPPC 2006).

3.11.1 Identification

Wiry rhizomes and climbing, twining fronds of indeterminate growth characterize Old World climbing fern. Leafy branches off the main leaf stalk above petiole constitute the pinnae; and are once compound with usually unlobed, stalked, articulate leaflets. The fern is homosporous and able to reproduce by three types of sexual reproduction (FLEPPC 2006).

Photo 14. Old World climbing fern.

3.11.2 Origin and Distribution

Old World climbing fern is native to Africa, Asia, and Australia. Compared to other invasives, Old World climbing fern is a more recently introduced invasive species to Florida, first recorded in 1958. By 1978, it had already begun smothering native shrubby and herbaceous vegetation (Nauman and Austin 1978). The range of distribution for this species is vast, as spores travel through wind-dispersal. Occurrences extend from peninsular Florida to Hernando and Duval counties. Old World climbing fern invades hardwood hammocks, mesic flatwoods, forested swamps, wet flatwoods, hydric hammocks, floodplain forests, strand swamps, and ruderal communities (Langeland *et al.* 2008).

3.11.3 Management Considerations and Options

High and continuous production of spores with very thick walls allows Old World climbing fern to propagate prolifically. Other characteristics that enhance this species competitive ability include plastic reproductive strategies and a high growth rate across light levels (FLEPPC 2006).

3.11.3.1 Physical Control – Manual/Mechanical Methods

Mechanical removal will temporarily reduce the biomass of Old World climbing fern, but infestations can return to pre-treatment levels within 12 to 17 months (FLEPPC 2006).

3.11.3.2 Physical Control – Prescribed Burning

Prescribed burning can prove difficult as Old World climbing fern poses management problems for prescribed fire as it provides a vertical path for fire to spread, creating crown fires and a loss of native bromeliads. Therefore, prescribed burning is not a recommended management practice in areas with canopy trees. Additionally, this species is fire tolerant and resprouts vigorously following wildfires (FLEPPC 2006).

3.11.3.3 Biological Control – Grazing

Due to security fencing requirements and other management limitations, grazing is not a recommended control.

3.11.3.4 Biological Control – Insects/Pathogens

Biological control, in conjunction with herbicide control, is the recommended management technique for Old World climbing fern. Three species have been approved for the biological control of Old World climbing fern. The Australian moth (*Austromusotima camptonozale*) is approved for field release by the US Department of Agriculture and is a specialist for *Lygodium* ferns (FLEPPC 2006). The eriophyid gall mite (*Floracarus perrepare*) reduces the growth of Old World climbing fern by

causing photosynthate to go to the gall instead of new growth. Another species, the pyralid moth (*Neomusotima conspurcatalis*) has a similar effect as the Australian moth, as well as similar specificity. These species have also been approved for field release as biological controls for Old World climbing fern (FLEPPC, 2006).

3.11.3.5 Herbicide Control

Ground or aerial treatment of Old World climbing fern with either glyphosate or Escort XP herbicides is recommended. Ground treatment often consists of cutting the rachis at three to five feet above ground level and spraying the base with 1 to 3% product glyphosate (FLEPPC 2006). Herbicide control is most effective when small populations of Old World climbing fern are treated before they become infestations.

3.12 Schefflera (*Schefflera actinophylla)*

Schefflera was observed only at JDMTA. Schefflera is listed as a Category I invasive exotic species by the FLEPPC. This tree threatens endangered remnants of scrub habitat by outcompeting native rare plants for light. Schefflera is very difficult to control and is especially invasive in undisturbed hardwood hammocks and pine rockland habitats.

3.12.1 Identification

Schefflera is an evergreen ornamental tree that grows quickly. The schefflera has shin, light green, oblanceolate leaves and large, red, showy flowers in dense clusters at stem tips during summer or autumn (Photo 15). Leaves can grow very large, and the entire leaf, including leaf stalks and leaflets, can be 3 feet long. Fruit is round, approximately ¼ inch in diameter, and a dark purplish black.

Photo 15. Flowering schefflera tree.

3.12.2 Origin and Distribution

Native to Australia, New Guinea, and Java, schefflera was introduced to Florida in 1927 and escaped cultivation in the late 1970s. Schefflera grows in full sun or partial shade, and can be found invading xeric hammocks, scrub, sand hill, beach dunes, maritime forests, hardwood hammocks, prairie hammocks, and ruderal communities. Schefflera has been documented 11 counties from Pinellas County and Brevard County to Miami-Dade and Monroe counties (Langeland *et al.* 2008).

3.12.3 Management Considerations and Options

Thousands of seeds with high germination rates are produced by a single schefflera tree, which are readily dispersed by birds and bats. Seedlings and young plants can be found in shaded areas as well as in sunny open areas (Gucker 2011). Schefflera can form dense thickets with a very dense root network.

3.12.3.1 Physical Control – Manual/Mechanical Methods

Schefflera seedlings and young plants should be pulled up by manual or mechanical methods, and fruits and branches removed from the treated area. Larger trees can be cut; however, follow-up treatments of herbicide application are required to prevent trees from sprouting.

3.12.3.2 Physical Control – Prescribed Burning

There is limited information available regarding schefflera's response to fire. Based on physiological (thin, bare trunks) and morphological characteristics of schefflera, it may be destroyed by fire. However, consideration must be made when the schefflera is growing as an epiphyte on another species that may or may not be able to survive fire.

3.12.3.3 Biological Control – Grazing

Grazing is not a recommended control.

3.12.3.4 Biological Control – Insects/Pathogens

There are currently no insects or pathogens being used for control of schefflera.

3.12.3.5 Herbicide Control

Schefflera is difficult to control with the use of herbicides. A cut-stump treatment with 50% GARLON 3A or 10% GARLON 4 is recommended, or if cut-stump application is not possible, a wide band of 10% GARLON 4 to the trunk of smaller individuals and 20% GARLON 4 on larger individuals (Langeland and Stocker, 2000). Effects of herbicide treatment may not be seen until months later, and repeated applications are necessary to avoid re-sprouts.

3.13 Wedelia (*Sphagneticola trilobata)*

Wedelia was observed only at PAFB. Wedelia is listed as a Category II invasive exotic species by the FLEPPC. This species spreads aggressively, and can form dense, vinelike thickets under dense canopy cover, thereby excluding native ferns and ground covers and crowding out nearly all other herbaceous species. Wedelia has the potential to exclude birds by eliminating their forage base, and reduces habitat for rodent and invertebrate populations (Langeland *et al.* 2008).

3.13.1 Identification

An herbaceous perennial, wedelia is a creeping, mat forming species with hairy stems. Leaves are opposite, papery to fleshy, with a rough, hairy lower surface. Flowers are solitary, approximately 1 inch in diameter, dark yellow, and resemble daisies.

Photo 16. Dense patch of wedelia.

3.13.2 Origin and Distribution

Wedelia is native to Central and South America, but has a history of cultivation as an ornamental plant. Reported in 24 counties primarily in central and south Florida, it is one of the most frequently occurring exotic species in south Florida, found in over 52% of surveyed lands (Langeland *et al.* 2008). Wedelia colonizes beach dunes, coastal berms, pine rocklands, prairie hammocks, disturbed uplands, scrubby flatwoods, sandhills, hardwood hammocks, swamps, freshwater marshes, lake edges, and maritime forests. It is tolerant of both salt and drought, and can grow in a range of conditions including moist soil, partial shade, full sun, total shade, rocky ground, and low nutrient soils (Langeland *et al.* 2008).

3.13.3 Management Considerations and Options

Fruits of wedelia are often infertile, but plants have rapid vegetative reproduction. The vine-like stems spread quickly from cuttings and broken pieces, and are tolerant of mowing. Plants will regrow

from the smallest cutting, so waste should be disposed of carefully. Wedelia is often accidentally moved due to mixing with crop seeds and other agricultural produce, and in soil.

3.13.3.1 Physical Control – Manual/Mechanical Methods

Mowing or slashing of wedelia should be avoided as plants can spread from cuttings. Hand pull and dig up runners, making sure to remove roots and rhizomes, followed by an application of glyphosate. Wedelia can also be controlled by removing the top few centimeters of soil using a hoe and burning the removed vegetation. The site should be rechecked periodically to ensure eradication, and plans should be developed for managing the treated site to prevent recolonization by other invasive species after wedelia is removed.

3.13.3.2 Physical Control – Prescribed Burning

Burning can be an effective means of control; however, plants are likely to sprout from surviving underground rhizomes. Therefore, mechanical removal of rhizomes following prescribed burning is recommended for large, widespread infestations of wedelia.

3.13.3.3 Biological Control – Grazing

Grazing is not a recommended control.

3.13.3.4 Biological Control – Insects/Pathogens

Wedelia spp. has no known biological control agents. Wedelia can be infested with chewing insects, leaf hoppers, and mites; however, these insects are seldom fatal.

3.13.3.5 Herbicide Control

Spraying metsulfuron-methyl (e.g. Escort®) herbicide with the addition of a suitable wetting agent, or application of 2,4-D, dicamba or 1-2% triclopyr can control the spread of wedelia. Smaller patches can also be treated with a 2% solution of glyphosate, or 5% solution for larger populations. Follow-up treatment is important as some underground runners will resprout after treatment (HEAR 2008). More dense populations can be treated with triclopyr ester.

4.0 Control Priorities and Recommendations

Control priorities were developed using the National Park Service (NPS) Exotic Species Ranking System (ESRS). This process analyzed each invasive species based on interactions between significance of impact (threat) and feasibility of control. The analysis of each invasive species allowed the establishment of priority rankings for the species present on the installation. This data is presented below in Figure 1 and the individual data summary forms are included as Appendix A.

Priority areas were determined using the NPS ESRS data forms for each invasive plant species observed during the field survey. The ranking system was designed by the NPS to rank invasive plant species. Priority rankings are based on the feasibility of control versus the degree of impact each invasive species has on the ecosystem at CCAFS, MTA, and JDMTA. The highest priority is given to the species that has the highest threat yet is still easy to control; the lowest priority would be the species that has the least threat and is difficult to control.

To prioritize the invasive plant species, the components of the ranking system were analyzed separately. Considerations were given to the locations and distributions of the invasive species, locations of the invasive species in relation to the natural barriers to seed bank dispersal, size of individuals, and presence of a native species in association with the invasive species.

Plants evolve over geologic time in response to physical and biotic processes characteristic of a region (e.g., climate, soils, rainfall distribution, drought, frost, and disturbance regimes) and interactions with the other species inhabiting the local community. Native plant communities at CCAFS, MTA, and JDMTA have been altered by prior land management practices (i.e., alterations of natural disturbances such as reduction in fire frequency and intensity and increased mechanical disturbances such as tracked and wheeled vehicle land clearing equipment). As a result, the current plant communities that exist at CCAFS, MTA, and JDMTA are interspersed with exotics that take advantage of unnatural and disturbed areas.

Due to the size of CCAFS and the high level of invasion, control of the weed species (especially Brazilian pepper) on this site will be relatively difficult and is anticipated to take many years to accomplish. However, control and eradication of these species can be achieved with active management. Recommendations for the control of each species are provided below.

In addition to the species discussed above, there are three other State-listed invasive species that occur on CCAFS, JDMTA, or MTA in small or isolated populations that should be carefully managed to eliminate their presence. The invasive species are earleaf acacia, guava, and camphor tree. Management recommendations for each of these species are provided below.

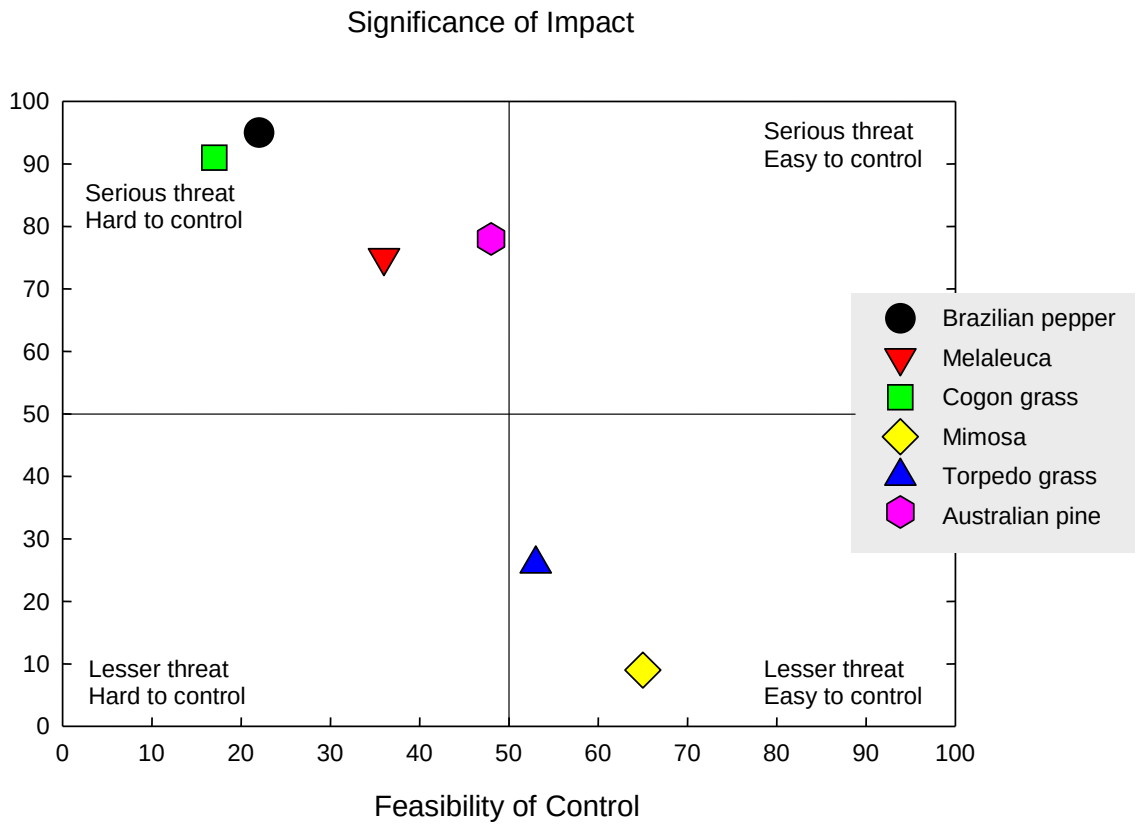

Figure 1. Feasibility of control versus significance of impact based on the National Park Service Exotic Species Ranking System.

4.1 Recommendations for the Control of Predominant Invasive Plants

CCAFS, PAFB, MTA, and JDMTA have several species that are listed as noxious by the State of Florida. The NPS ESRS evaluation determined that five of those species are in or near the "Serious threat, Hard to control" quadrant, Brazilian pepper, Australian pine, cogon grass, Old World climbing fern, hydrilla, torpedo grass, and melaleuca. Control and eradication of these species can be achieved with active management. Recommendations for the control of each species are provided below. Mention of an herbicide brand name should not be taken as an endorsement of the product or of the company that produces that product.

SPECIES	RECOMMENDATIONS
Brazilian pepper 	Due to the extensive distribution of Brazilian pepper on all four installations, it is recommended that an integrated treatment of mechanical methods with herbicide use and prescribed burning be implemented over several years. Cutting the trees down and treating the stumps with herbicide can control Brazilian pepper. A saw or brush cutter, should be used to cut the trunk as close to the ground as possible. Within 5 minutes, an herbicide that contains the active ingredient glyphosate or triclopyr should be applied as carefully as possible to the cambium, which is just inside the bark of the stump. Care should be taken to avoid touching the cambium as a skin rash may result. Near water, treat the stumps with an aquatic glyphosate product such as Rodeo® or Aquamaster™ at a rate of 4 pounds per gallon. For dry sites, use a glyphosate product such as Roundup Pro® or Glyfos® Pro at 3 pounds per gallon or broadcast spray 2 to 5 quarts per acre. Seedlings can be treated spray-to-wet with 1½ percent solution of glyphosate using hand-held equipment. Triclopyr ester (e.g., Garlon 4®) applied using the basal-bark method at a 0.5 to 1.5 percent rate is recommended for killing large trees that are found around some of the retired launch sites. Triclopyr is not approved for use on North American Air Force bases. Burning affects Brazilian pepper seeds, seedlings, and saplings and should be used as a follow-up to an herbicide treatment. Treatment should be performed early in the year before the Brazilian pepper enters its active fruiting stages. However, care should be taken because some individuals fruit throughout the year.

SPECIES	RECOMMENDATIONS
Australian pine 	Manual removal of Australian pine seedlings and saplings is recommended for new or small infestations. Heavier infestations will require an application of a systemic type herbicide to bark, cut stumps, or foliage for effective management. If the treated population is in an area that will support burning, the debris layer should be burned to reduce the seedbank, and native vegetation should be replanted in the area. Using the basal bark method, apply a 2 percent mixture of triclopyr ester (e.g., Garlon 4®) in diesel oil with a small sprayer in an 18 inch band around the tree 6 to 12 inches above the ground. A second treatment may be necessary for large trees. Triclopyr is not approved for use on North American Air Force bases. A mixture of isopropylamine salt of imazapyr (e.g., Arsenal®) and glyphosate (e.g., Roundup® Pro) can also be sprayed using the basal bark method. Use 4 to 6 pints of Arsenal® and 2 to 5 quarts of Roundup® Pro per acre. Apply after full leaf expansion, and allow 7 or more days before removal of the plants. In arid areas, apply in spring to early summer when there is high moisture content. Follow isopropylamine salt of imazapyr Florida supplemental instructions. Imazapyr is highly active in soil and has a potential for leaching into groundwater; it should only be used when groundwater impacts can be eliminated or minimized.

SPECIES	RECOMMENDATIONS
Old World climbing fern 	Herbicide control of Old World climbing fern with 1 to 3% glyphosate applied to the base of rachis cut three to five feet above ground level. It is imperative to successful treatment that small populations be immediately treated before they are allowed to become large infestations. Mechanical removal often proves difficult due to the plants ability to rapidly regenerate from spores which are impossible to prevent or remove. Prescribed burning is not recommended as vertical vines provide a pathway for fire to tree crowns, and create unsafe burning conditions. Depending on the size of the infestation, biological controls may be used in conjunction with herbicide application. The Australian moth, eriophyid gall mite, and pyralid moth are all approved for field release as biological controls for Old World climbing fern. These may provide successful eradication in large populations of the plant.

SPECIES	RECOMMENDATIONS
Chaste tree 	A combined approach of herbicide control and manual/mechanical removal can is recommended for Chaste tree removal. Small saplings can be hand pulled or dug out, and larger shrubs can be removed with machinery when the surrounding environment permits. Large machinery should not be used for removal of Chaste tree in areas that are ecologically sensitive, such as sand dunes and other coastal areas. All remnants of the root and stem fragments should be removed to prevent reestablishment of the plant. Several herbicide treatments are available to treat Chaste tree. Selection of herbicides should consider nearby ecologically sensitive areas (such as sand dunes and other coastal habitat) and the presence of other broadleaf or grass plants that may be damaged by the herbicide. Glyphosate should be applied to cut stumps or wounded stem, and oil based herbicides should be applied to the base of the stem in a band. When applying imazapyr (e.g. Aresenal®), follow isopropylamine salt of imazapyr Florida supplemental instructions. Imazapyr is highly active in soil and has a potential for leaching into groundwater; it should only be used when groundwater impacts can be eliminated or minimized.

SPECIES	RECOMMENDATIONS
Cogon grass 	An integrated approach that combines burning, mechanical disturbance (e.g., tillage), and herbicide applications should be used to control cogon grass infestations. Once good control of cogon grass has been achieved, it is essential to introduce desirable vegetation as quickly as possible to prevent cogon grass (or Brazilian pepper) from re-infesting the area. To control cogon grass, burn or mow it in the early summer to remove excess thatch and older leaves. This initiates regrowth from the rhizomes, thereby reducing rhizome biomass. It also allows herbicides to be applied to only actively growing leaves, maximizing herbicide absorption into the plant. Ideally, burning should take place in the summer. A one to four month regrowth period has been shown to provide a sufficient level of leaf biomass for herbicide treatment. Applications of isopropylamine salt of imazapyr at 16 ounces per acre or glyphosate at 3 to 4 quarts per acre should be made in the late summer or early fall. Follow isopropylamine salt of imazapyr Florida supplemental label instructions. Because imazapyr is highly active in soil, it has a high potential for leaching into groundwater, and should only be used when groundwater impacts can be eliminated or minimized. Since imazapyr remains in the soil for long periods, its effectiveness on cogon grass and other plants may continue up to a year after application. Till the site a few weeks after herbicide application and plant a competitive imazapyr-resistant cover crop. Once good control of cogon grass has been achieved, it is essential to introduce desirable vegetation as quickly as possible to prevent cogon grass from re-infesting the area. Cogon grass will eventually begin to re-infest, regardless of control. Diligence and persistence are essential to control re-infested areas before cogon grass re-establishes.

SPECIES	RECOMMENDATIONS
Melaleuca 	All of the melaleuca trees are planted in areas that are regularly mowed and maintained. These practices will generally prevent further spread and establishment of a viable population. If an area containing a melaleuca tree is no longer receiving regular mowing the tree should be removed and the stump treated with an herbicide to prevent regrowth. If any melaleuca trees are growing near water where their seeds could be readily dispersed, then these trees should be removed. Trees that need to be removed should be frilled/girdled or cut, and the cambium or stump treated with an herbicide to prevent regrowth. Isopropylamine salt of imazapyr (e.g., Arsenal®) in a 50 percent solution with water or 4 to 6 pints per acre applied with the frill/girdle or cut-stump methods of application, is effective in controlling melaleuca. Imazapyr has a high likelihood of leaching into groundwater, and should only be used where groundwater effects can be eliminated or minimized. A stressful event such as girdling and herbicide application will cause the tree to release millions of seeds from their capsules, so follow-up treatment within two years of the initial treatment is recommended.

SPECIES	RECOMMENDATIONS
Torpedo grass 	Since torpedo grass has numerous dormant buds associated with extensive rhizomes, this species is extremely difficult to control and herbicides are the recommended first line of attack. Herbicide controls should be used so that the herbicide will be transported to the root system. Multiple applications may be necessary to control this species. A glyphosate product for aquatic environments (e.g., Rodeo®, Aquamaster™) at a rate of 6 to 7.5 pints per acre plus 2 or more quarts of a nonionic surfactant will partially control torpedo grass. Use the lower rates for terrestrial sites and the higher rates for partially submerged or floating mats of vegetation. Apply when plants are actively growing and most have reached early head or early bud stage. Allow at least 7 days before removing vegetation. Re-apply as necessary when plants regrow up to 4 to 6 inches in height. A 0.5 percent solution of isopropylamine salt of imazapyr (e.g., Arsenal®) as a spot treatment or broadcast at 3 to 4 pints per acre will also provide partial control. Follow Florida supplemental label information. Imazapyr has a high likelihood of leaching into groundwater, and should only be used where groundwater effects can be eliminated or minimized. Small populations can be removed by pulling or cutting the vegetation with hand tools. This may need to be done more than once in a growing season. The best time for hand removal of torpedo grass is after seedhead production but before flowering. Pulling the roots is not generally recommended since it may stimulate new shoot production.

SPECIES	RECOMMENDATIONS
Mimosa 	An integrated approach of mechanical and herbicide treatment is recommended for the control of mimosa located at CCAFS, PAFB and MTA. Mimosa trees should be cut down and deposited in an approved landfill. Once the trees have been cut immediately apply a 25 percent solution of glyphosate and water to the cut stump covering the outer 20 percent of the stump. This will prohibit resprouting from the trunk and control potential shoots. Occasional treatment of the area with an herbicide will be needed to prevent establishment of individuals sprouting from a developed seed bank. Seedlings and small trees can be controlled by applying a 2 percent solution of glyphosate (e.g., Roundup®) or triclopyr (e.g., Garlon®) and water plus a 0.5 percent non-ionic surfactant, thoroughly wetting all leaves. These herbicides can kill entire plants because the herbicides travel through a plant from the leaves and stems to the actively growing roots, where they prevent further cell growth. Use a low pressure, coarse spray pattern to reduce damage from spray drift on non-target species. Triclopyr is not approved for use on North American Air Force bases.

4.2 Recommendations for the Control of Other Species

In addition to the species discussed above, the following state-listed invasive species that occur on CCAFS, JDMTA, or MTA in small or isolated populations that should be carefully managed to eliminate their presence. These invasive species are earleaf acacia, guava, and camphor tree. Management recommendations for each of these species are provided below.

SPECIES	RECOMMENDATION
Earleaf acacia 	Very little is known about the control of earleaf acacia. For infestations found on JDMTA, trees should be controlled using a similar control method as used on melaleuca and mimosa. Trees should be removed and the stump treated with an herbicide to prevent regrowth. Trees can be frilled/girdled or cut, and the cambium or stump treated with an herbicide to prevent regrowth. Isopropylamine salt of imazapyr (e.g., Arsenal®) in a 50 percent solution with water or a 25 percent solution of glyphosate and water to the cut stump covering the outer 20 percent of the stump. Imazapyr has a high likelihood of leaching into groundwater, and should only be used where groundwater effects can be eliminated or minimized. Occasional treatment of the area with an herbicide will be needed to prevent establishment of individuals sprouting from a developed seed bank. Seedlings and small trees can be controlled by applying a 2 percent solution of glyphosate (e.g., Roundup®) or triclopyr (e.g., Garlon®) and water plus a 0.5 percent non-ionic surfactant, thoroughly wetting all leaves. Smaller trees or shoots can be hand pulled. It is recommended that they be pulled when the ground is moist to ensure roots are removed.

SPECIES	RECOMMENDATIONS
Camphor tree 	Camphor tree is heavily used as a landscape species and very little is known about its control. For infestations found on MTA, trees should be controlled using a similar control method as used on earleaf acacia, melaleuca, and mimosa. Trees should be removed and the stump treated with an herbicide to prevent regrowth. Trees should be frilled/girdled or cut, and the cambium or stump treated with an herbicide to prevent regrowth. Isopropylamine salt of imazapyr (e.g., Arsenal®) in a 50 percent solution with water or a 25 percent solution of glyphosate and water to the cut stump covering the outer 20 percent of the stump. Imazapyr has a high likelihood of leaching into groundwater, and should only be used where groundwater effects can be eliminated or minimized. Occasional treatment of the area with an herbicide will be needed to prevent establishment of individuals sprouting from a developed seed bank. Seedlings and small trees can be controlled by applying a 2 percent solution of glyphosate (e.g., Roundup) or triclopyr (e.g., Garlon®) and water plus a 0.5 percent non-ionic surfactant, thoroughly wetting all leaves. Smaller trees or shoots can be hand pulled. It is recommended that they are pulled when the ground is moist to ensure that the roots are removed.
Guava 	Manual and mechanical control measures work reasonably well when removing strawberry guava and are recommended where practical. Seedlings and saplings originating from seed can be uprooted. Stems up to two inches (basal diameter) can be uprooted with a weed wrench, although some roots may need to be cut once the plant is partly uprooted. Uprooted plants may resprout or re-root if the plants are set on the ground. Slash should be removed since manual and mechanical methods are less effective on root sprouts.

4.3 Recommendations for Minimizing Movement of Exotic Species

45 CES/CEIE-C minimizes the movement of exotic vegetation onto 45 SW properties. 45 SW contractors that utilize heavy equipment within 45 SW properties should have a contract clause stating the contractor is responsible for equipment inspection for invasive speeds (rhizomes, seeds, cuttings) prior to entering an installation. This includes inspection of heavy equipment vehicles that are coming onto 45 SW properties, and vehicles that are exiting the properties will be inspected prior to leaving the properties.

4.4 Location of Exotic Species on 45 SW Mainland Florida Properties

The following maps (Figures 2 and 3) depict the areas on CCAFS and PAFB that contain invasive species, as of 2013. For the purpose of treating invasive exotic plant species, the CCAFS installation has been subdivided into nine discrete units. The first eight units will be further subdivided for treatment. Each year for the next five years areas will be delineated to be treated either mechanically and/or chemically to reduce the acreage impacted. These subdivided areas will be tracked and the polygonal units will be monitored with Global Positioning System (GPS) unit to delineate the removal of exotic vegetation. The Skid Strip area (Unit 9) has been cleared and grubbed as a part of the Skid Strip improvement plan. This removed all vegetation from the area and replaced it with grass to facilitate maintenance and reduce erosion. Unit 9 will not be included in the 45 SW ISCP. The focus of the ISCP regarding CCAFS will be the areas that are included in the other eight units. In areas where habitat restoration will be accomplished, the exotic vegetation will be mechanically treated followed by an application of an herbicide six to nine months after it has been burned. Where there is no overlap with habitat restoration, these areas will be identified and targeted in an annual invasive species project. The primary method of treatment will be to mechanically mulch vegetation when not in seed or totally removed when in seed, with a follow on herbicide application for each area treated. The area along the west side of the CCAFS (Unit 8) will require more intense effort; it is not located in any burn compartment and several projects will need to be developed to treat this area. A project, DBEH 077295 CONS-INVASIVE SPRAYING AERIAL APPLICATION, has been developed to apply herbicides using a helicopter on the Trident and Poseidon spoil areas. These two areas encompass about 100 acres and are mainly comprised of exotic vegetation.

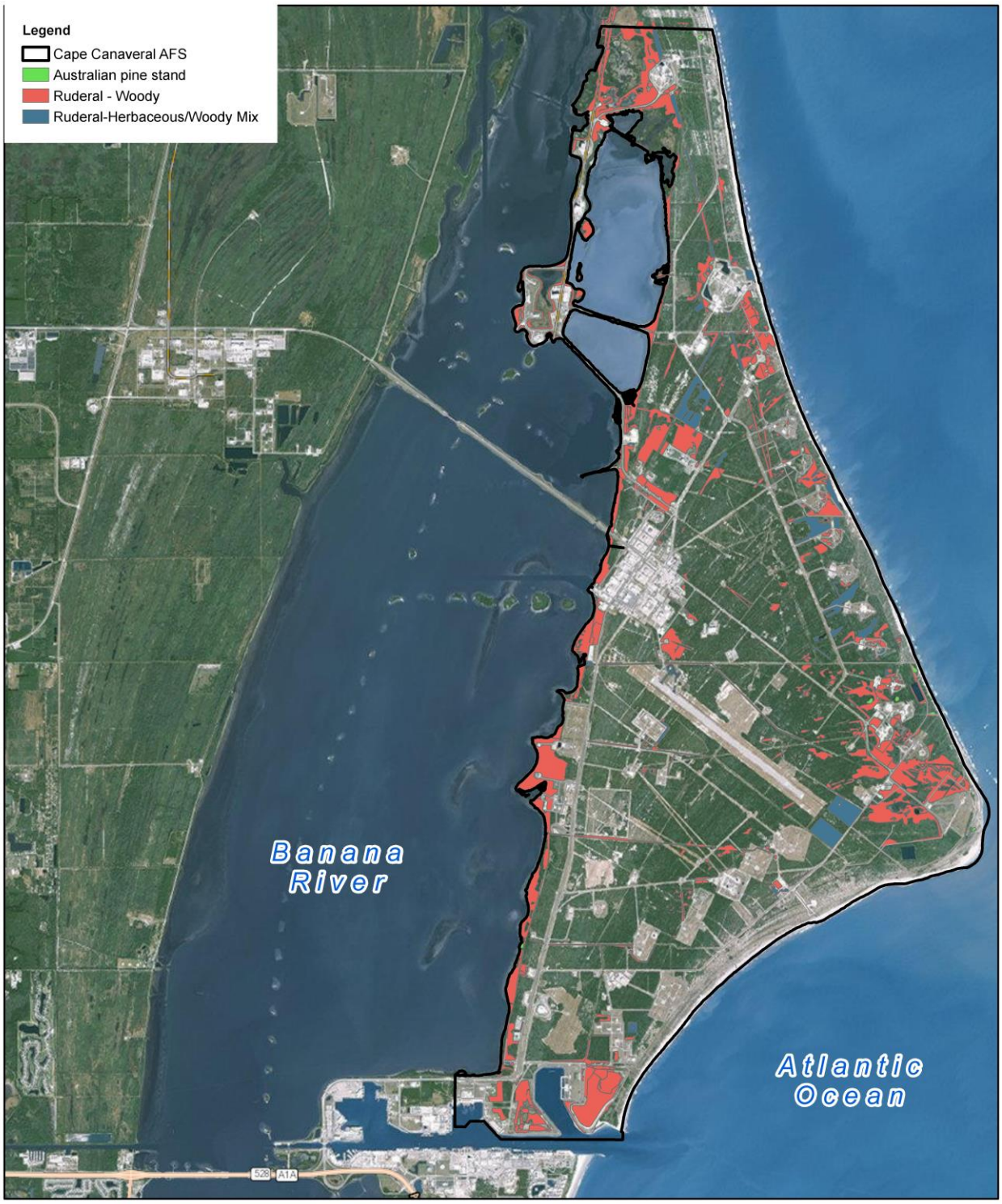

Figure 1. Invasive Vegetation at CCAFS (2013)

Figure 2. Invasive Vegetation at PAFB (2013)

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6.0 DEFINITIONS

(a) ‘‘Alien species’’ means, with respect to a particular ecosystem, any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem.

(b) ‘‘Control’’ means, as appropriate, eradicating, suppressing, reducing, or managing invasive species populations, preventing spread of invasive species from areas where they are present, and taking steps such as restoration of native species and habitats to reduce the effects of invasive species and to prevent further invasions.

(c) ‘‘Ecosystem’’ means the complex of a community of organisms and its environment.

(d) ‘‘Introduction’’ means the intentional or unintentional escape, release, dissemination, or placement of a species into an ecosystem as a result of human activity.

(e) ‘‘Invasive species’’ means an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health.

(f) “Noxious species” means a plant species that has been designated “noxious” by law. The word “noxious” simply means deleterious, and all weeds are deleterious by definition.

(g) ‘‘Native species’’ means, with respect to a particular ecosystem, a species that, other than as a result of an introduction, historically occurred or currently occurs in that ecosystem.

(h) ‘‘Species’’ means a group of organisms all of which have a high degree of physical and genetic similarity, generally interbreed only among themselves, and show persistent differences from members of allied groups of organisms.