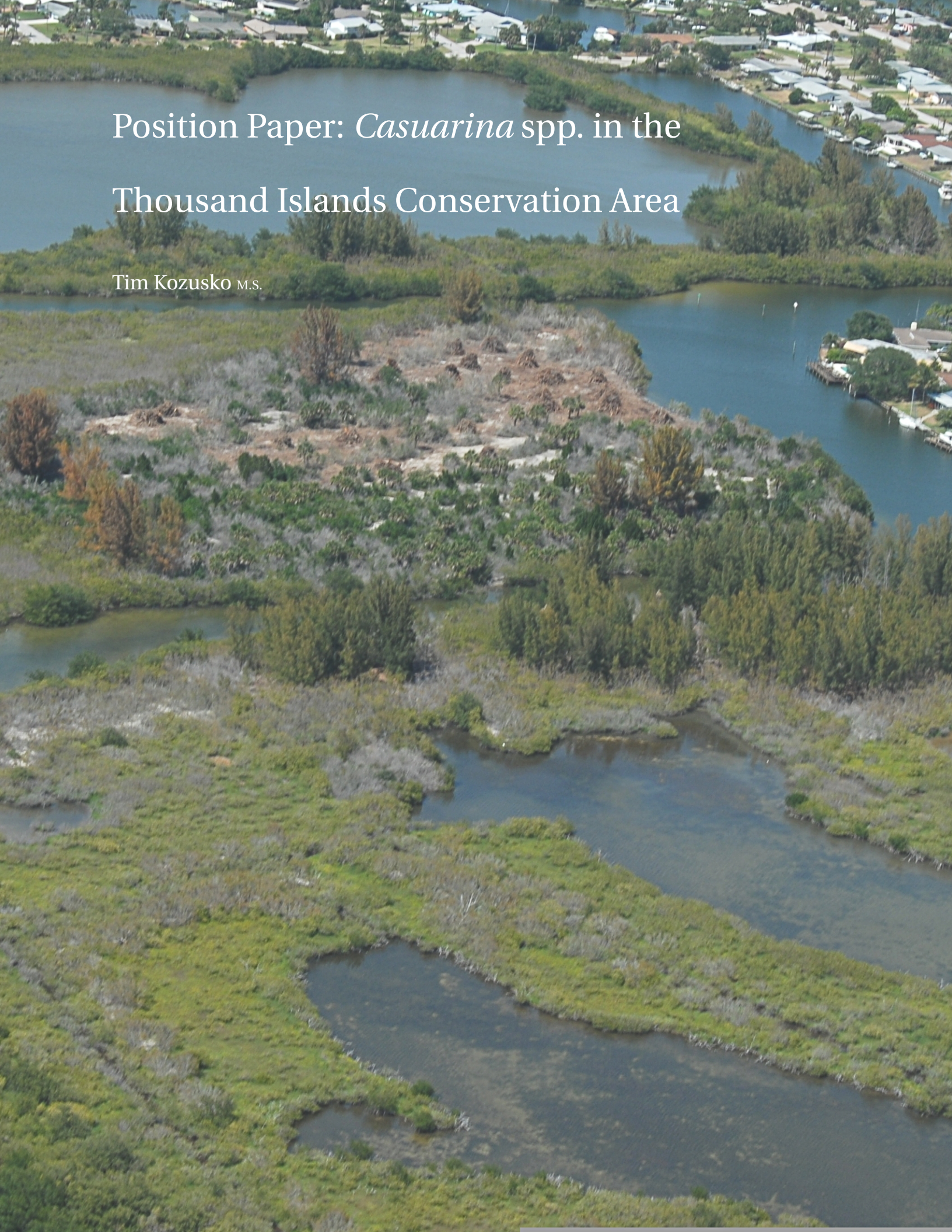

Position Paper: *Casuarina* spp. in the Thousand Islands Conservation Area

Tim Kozusko M.S.

COVER: North Crawford Island in mid-restoration. Photo taken May 4, 2009. The area where these trees were removed is now alive with many more species of plants and animals than had previously been seen there. The job is incomplete; the remainder of these trees should be removed as soon as possible. Photo by T. Kozusko.

Executive Summary

There are a few major points I would like to make, followed by explanations to provide the background necessary for a minimalist picture of the situation. Please understand that ecology is a complicated science. There are fundamental aspects of ecology that are covered over several upper-level and graduate level courses in a degree program. I cannot convey the nuances of these concepts in a few pages any more than a set of blueprints can convey the engineering theory behind the decision to build a bridge a certain way, and of specific materials. In no way does this limitation invalidate ecological theory, any more than the similar limitation in blueprints invalidates the theory behind materials science.

A note on nomenclature: when referring to the entire formation I will call it the Thousand Islands. When referring to that portion of the Thousand Islands (colloquially known as the “south islands") acquired to be managed by Brevard County Environmentally Endangered Lands Program (EEL) I will call it the Thousand Islands Conservation Area (TICA). When referring to the (“north islands") acquired in the 1980s I will call it the north Thousand Islands.

Forgive me, but as a biologist I must admit that I am at times frustrated by the involvement of Cocoa Beach in the *specifics* of land management decisions in the TICA. [1] I see this as meddling, and as compromising the primary purpose for the acquisition of this land — the restoration and preservation of biological diversity. Not camping. Not gardening. Not someone’s idea of what a pretty kayak paddle should be. This is supposed to be science-based conservation of biological diversity.

[1] I do understand and appreciate the sense of ownership felt in Cocoa Beach. I was born there and was a large part of the effort to acquire the TICA. But as I stated when we asked for EEL’s help, we need to let them manage it.

The TICA was purchased chiefly with money given by others, with the stipulation that the lands be managed in a scientifically defensible manner, so as to restore and promote biological diversity. Recently proposed actions to preserve a tree species known to be ecologically damaging are at odds with the scientifically defensible management of these conservation lands. With one possible exception that does not involve the TICA, I view the “preservation" of Australian pine as totally unacceptable. [2]

[2] This exception will be noted in the body of this document.

I wish to make the following points about the TICA, hopefully in a manner that educates rather than condemns:

- Australian pine is rated as a Category I invasive exotic plant, the most serious rating given to non-native vegetation in Florida by experts in the field. It is not a classification given capriciously.
- Decades of peer-reviewed science has established the great ecological harm resulting from infestations of this tree.
- The “preservation" of these trees flies in the face of the stated goals of the Environmentally Endangered Lands Program, and the Florida Communities Trust, both of whom put up the majority of the money that

enabled acquisition of this area. The TICA was, by definition, acquired and set aside to protect biological diversity as the primary goal. The continued presence of Australian pine is in conflict with this goal.

- Allowing these invasive trees to remain in part of the TICA provides an opportunity for them to spread into other areas — that is why they are referred to as *invasive* — thus putting other areas at risk. [3]
- There is an ecosystem-level cost associated with allowing these trees to remain in places. The cost manifests itself in the form of reduced ecosystem services and impacts to biological diversity and biomass. [4]
- However well-intentioned, a group of lay people attempting to influence specific land management decisions undermines the integrity of the EEL program, a program whose land management decisions are supposed to be guided by science, not uninformed opinion.

[3] Imagine an oncologist leaving part of a tumor in.

[4] Far too complicated a concept to describe adequately in a work short enough to be read, but I shall try.

This is not conservation. These trees attract this element of humanity the same way a rotting fish attracts flies. Setting aside the question of liability, the stated purpose of EEL and the TICA acquisition should invoke the precautionary principle. Camping is rarely passive; it has ecological impacts. Without monitoring, which no one has resources to support, how will these impacts be controlled? Better not to allow it in the first place.

Introduction

It has come to my attention that the City of Cocoa Beach is considering a formal request to *preserve* a few stands of Australian pines in the TICA. This is a bad idea. It is ecologically harmful, and I believe it betrays the agreement Cocoa Beach entered into when it accepted Florida Communities Trust and EEL funding to acquire the islands.

I am a native of Cocoa Beach with 45 years experience in the Thousand Islands. I sat on the Waterways/Wildlife Advisory Board and the Land Management Committee for several years. I volunteer with the Brevard County Environmentally Endangered Lands Program (EEL). I am a biologist at John F. Kennedy Space Center, though I hasten to add that my views in no way reflect those of EEL, my employer, or the National Aeronautics and Space Administration.

I was involved in efforts to acquire the TICA and am a popular public speaker with over 15 years experience giving lectures on the ecology of the Thousand Islands and guiding tours through and on the islands. Together with my wife and fifth grade teacher Laura, I created the Kayaks & Compasses field trip that has exposed hundreds of Freedom 7 students and parents to the Thousand Islands as a “living laboratory" over the past 10 years. My work is cited in both management plans for the Thousand Islands.

I have conducted several vegetation research projects in the TICA with two in preparation for submission to peer reviewed journals for publication. I hold a master of science degree in biology from the University of Central Florida and am currently a doctoral student at the Florida Institute of Technology in science education with biology as the major technical area.

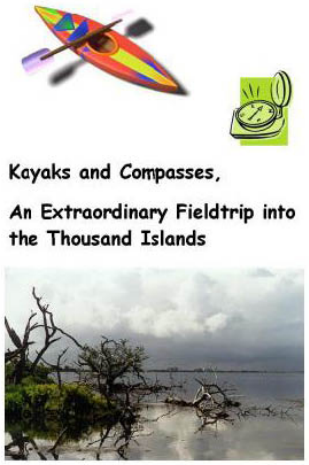

Figure 1: Cover of the booklet used for the Kayaks & Compasses field trips.

Short history of EEL

It is instructive to examine how this program came to be. In 1984 Brevard voters passed a referendum called the Beach and Riverfront Program. [5] This was a twenty-year tax of up to a half mil that focused on access to the beach and inland waterways, not conservation. The decisions on which properties to acquire were made by commissioners and county staff. A general lack of transparency in the process of site selection, and no funding for management of the acquired properties led to some problems with public perception.

In 1989 Brevard residents failed to pass a referendum for environmental lands acquisition. Several factors are thought to have led to the failure. One was the negative public perception of the Beach and Riverfront Program. Another was the recent move of the government center to Viera, which was funded via certificates of participation, rather than by referendum.

[5] P. Schmalzer, Personal Communication, 2011

The county commission adopted a conservation model based on that of Volusia County, and appointed a committee of citizens to develop a Land Acquisition Manual for an environmentally endangered lands program before bringing the program back up for another vote. The Land Acquisition Manual was approved by the commission in July, 1990.

The primary driver of the Land Acquisition Manual (LAM) was conservation, with passive recreational use, education, and scientific research as secondary priorities. Another outcome of the LAM was the formation of a Selection Committee (SC) of seven scientists who would review and recommend parcels for consideration by the commission. Purchases, member selection, bonding, and budget were to be determined by the commission.

Land management was to be science-based to maintain biological diversity through use of prescribed fire, elimination of exotic species, and control of unsustainable uses such as all-terrain vehicles and dumping. The SC was appointed in August of 1990, before the referendum passed. In September 1990 the referendum passed with 60% of the vote. In 2004 Brevard residents again overwhelmingly passed a referendum to extend EEL funding.

Thousand Islands acquisitions

In 1986 the city of Cocoa Beach began to seek help in acquiring the Thousand Islands for conservation. [6] The Thousand Islands north of Minutemen causeway were acquired by a consortium of Cocoa Beach, Brevard County, and the State of Florida in 1988. In early 1991 Brevard County staff submitted a CARL proposal for a series of properties which included the remaining Thousand Islands. This was rejected. [7]

Working alone Cocoa Beach submitted grants to the Florida Communities Trust to acquire the remaining islands in 2001 and again in 2006. I was involved with these efforts. In both instances the grants were approved but price negotiations failed. Following this the city of Cocoa Beach requested that EEL become grant recipient and manage the islands. [8]

The Crawford parcel (61 acres) was acquired by EEL in 2006. On October 23, 2007, the county commission voted to approve purchase of the Reynolds tract of the south Thousand Islands — a section long popular with kayakers. This parcel, 275 acres, was finally acquired in 2008. Removal of Brazilian pepper and phased removal of Australian pine began in 2009 at 4th Street South and part of the Crawford parcel.

[6] City of Cocoa Beach. Thousand Islands management plan, 1994. Website: `http://www.cityofcocoabeach.com/FlashHomePages/Search_home.html`

[7] P. Schmalzer, Personal Communication, 2011

[8] Brevard County EEL. Management plan Thousand Islands Conservation Area. `http://www.brevardcounty.us`, 2008

Ecological Description of the Thousand Islands

Origin and modifications

Though many of these islands have been modified by mosquito control and dredge and fill, the Thousand Islands formation is natural. The Thousand Islands landform is technically described as the relict shoals of a flood tide delta deposit. In other words the Thousand Islands are the remains of a former inlet. The time of inlet formation is not known, but inlets in the Indian River Lagoon generally move to the south and finally close due to longshore sediment transport, 200 to 300 years after the inlet formation. [9] In the image below the south Thousand Islands are seen in roughly their original configuration.

[9] R. Parkinson, Personal Communication, 2007

Figure 2: Aerial view of south Thousand Islands in 1951, prior to any significant development. Note original causeway to Merritt Island at top of image, roughly where Minutemen Causeway is located now.

Following World War II the Thousand Islands have been heavily impacted by development and mosquito control. In late the 1950s dredge and fill activities were begun in Cocoa Beach for housing development.

This process involved dredging of canals to provide fill material, allowing houses to be built in what had previously been salt marsh. A significant portion of the original Thousand Islands was lost to development in the period spanning the late 1950s to early 1960s.

Figure 3: Aerial view of south Thousand Islands in 1958, at the beginning of dredge and fill for housing development. White areas are newly dredged bare sand.

Few people understand the capacity of Florida salt marshes to produce mosquitoes, and the role mosquito control has played in the present ecology of Florida's salt marshes. [10] In early efforts mosquito control almost exclusively relied on pesticides. In fact, the first DDT field trials in North America were performed in a low area of south Cocoa Beach. [11] And it was here that the evolution of DDT resistance was first observed.

Saltmarsh mosquito species do not lay eggs in standing water. They instead choose sand or mud that is only seasonally flooded. This is an excellent defense mechanism against predators. In mosquito control known as "source reduction" the salt marsh is modified to remove as much of these seasonally-flooded ponds as possible, reducing breeding habitat.

[10] G. Patterson. *The mosquito wars, a history of mosquito control in Florida.* University Press of Florida, Gainesville, 2004. 264 pp

[11] J. Beidler, Personal Communication, 2011

Figure 4: Ground-level view of a small seasonal pond, surely loaded with mosquito eggs that can persist like this for months. When the rainy season begins, small ponds such as this fill and the eggs hatch.

Beginning in the late 1950s small, shallow ditches were dug through the low salt marsh to allow fish access to inner areas of salt marsh for mosquito control. [12] It was thought that this would allow fish to eat mosquito larvae, thus controlling them. The efforts were minimally successful in reducing mosquito populations.

[12] J. Salmela, Personal Communication, 2000

Figure 5: Aerial view of rotary ditches in the Thousand Islands, 1999. The major ecological impact was to allow the spread of mangroves to the island interior fringes.

During the late 1960s deeper ditching by dragline was begun in the south Thousand Islands in a stronger effort to control mosquitoes. The islands south of Minutemen Causeway were more heavily impacted in this way than those islands to the north. As the environmental movement began following publication of Rachel Carson's seminal book *Silent Spring*, the value of salt marshes gradually began to be appreciated. Dredging of

mosquito canals was suspended in the early 1970s, largely due to concerns about impacts of this practice to the ecology of salt marshes and mangroves. As the Apollo program was canceled demand for houses waned, reducing pressure to develop any more of the islands.

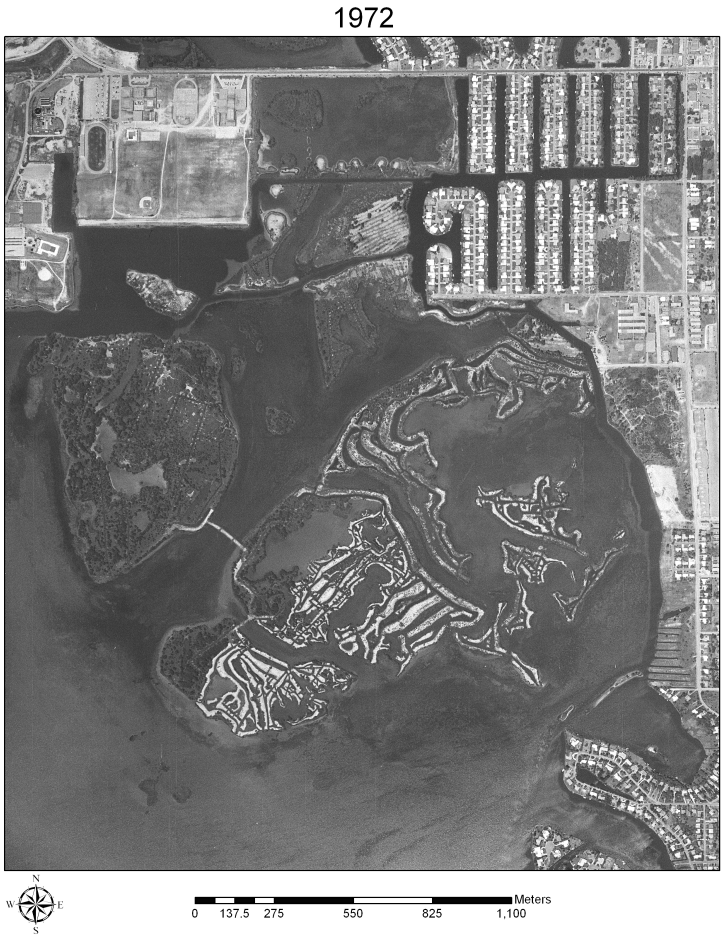

Figure 6: Aerial view of mosquito canals in the Thousand Islands, 1972. Note diked areas still sparsely-vegetated.

The impact on vegetation from dredging mosquito canals was dramatic. Salt marsh was converted either to mosquito canal or raised dike, allowing colonization by upland vegetation, including exotics. This removed much of the source habitat for mosquitoes. However, it also eliminated foraging habitat for shore birds and spawning habitat for horseshoe crabs.

The soil surface was raised significantly above the water table on dikes. This allowed colonization by upland plants and trees not previously present in the Thousand Islands. The disturbance also allowed invasive non-native tress, particularly Brazilian pepper (*Schinus terebinthifolius*) and Australian pine (*Casuarina* spp.) to dominate many areas of the islands.

Figure 7: Aerial view of mosquito canals in the Thousand Islands, 1999. Wetland habitat has been virtually eliminated, remaining only as fringing mangroves along island edges.

Vegetation Communities

Introduction

Climate, soils and drainage influence the plants present in a given area. Florida is home to many different plant community types. The official list is compiled by the Florida Natural Areas Inventory (FNAI — usually pronounced “effnay"). [13] For the purposes of this work I draw slight distinctions between the names I use for the plant communities in the Thousand Islands and their FNAI equivalents, noting them where different. [14]

[13] Florida Natural Areas Inventory. Guide to the natural communities of Florida: 2010 edition. 2010

[14] T. J. Kozusko. Unpublished species list of plants found in the Thousand Islands. 2012

- Native wetlands and island fringes (The term “native wetlands" refers to areas in which the soil topography has not been altered. The term “island fringes" refers to the edges of mosquito dikes that are wet enough to support obligate wetland plants.)
  - Mangrove swamp
  - Succulent salt marsh (FNAI “salt marsh")
  - Graminoid salt marsh (FNAI “salt marsh")
- Transition
  - Graminoid transition (No FNAI equivalent)
  - Woody transition (No FNAI equivalent)
- Uplands
  - Dredge spoil (No FNAI equivalent)
  - Tropical maritime hammock

Succulent salt marsh

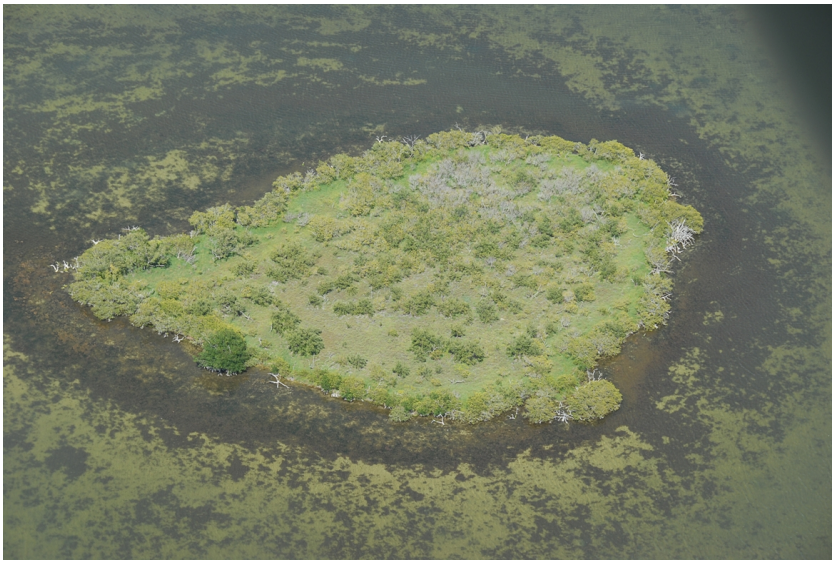

Figure 8: Aerial view of Mattheson Island (approximate area of 0.57 ha) an unmodified island containing succulent salt marsh with fringing mangroves. A few smaller mangroves are located in the island interior, but limited by infrequent freezes. Succulent species include annual and perennial glasswort (*Salicornia bigelovii* and *Sarcocornia ambigua*), saltwort, (*Batis maritima*), and sea blight (*Suaeda linearis*).

Figure 9: Ground-level view of same island, showing succulent plant species, white mangrove (*Laguncularia racemosa*) in foreground, black mangrove (*Avicennia germinans*) in background. This is what the vast majority of the Thousand Islands looked like prior to dredge and fill.

Transitional

Figure 10: Ground-level view of transitional zone between salt marsh and uplands. Vegetation includes sea oxeye daisy (*Borrichia frutescens*), and two types of salt grass (*Distichlis spicata* and *Paspalum vaginatum*). Some transitional zones are inhabited by buttonwood (*Conocarpus erectus*).

Figure 11: Aerial view of dredge spoil, transitional zone, and salt marsh in north Thousand Islands. The part of the island in the upper portion of the image is succulent salt marsh and fringing mangroves. The lower part of the image to the right is a slightly higher portion of dredge spoil inhabited by privet (*Forestiera segregata*), oaks (*Quercus virginiana*), and red cedar (*Juniperus virginiana*). The central part is lower uplands and some transitional zone infested with Australian pine.

Dredge spoil

Figure 12: Aerial view of dredge spoil. Uppermost island is Salmela shell midden and tropical maritime hammock.

Figure 13: Ground-level view of dredge spoil on north Crawford Island, after removal of Australian pines. Visible in image at cabbage palm (*Sabal palmetto*), privet (*Forestiera segregata*), wax myrtle (*Myrica cerifera*), and red cedar (*Juniperus virginiana*).

Tropical maritime hammock

Figure 14: Aerial view of C-34 impoundment showing Provost shell midden area and tropical maritime hammock. The perimeter dike was carried inside the hammock to prevent its destruction when the impoundment was flooded.

Figure 15: Ground-level view of Provost Native American shell midden and dense tropical shrub species. Many of these plants are not found much farther north than Brevard County.

Figure 16: Ground-level view of same general area of north Crawford island where I have a long-term vegetation monitoring transect. From top down, 2007 with Australian pine (and little else), 2009 just after removal of Australian pine, and 2011 showing heavy natural native recruitment overwhelming planted shrubs. The lower image is obviously not able to depict the dramatic increase in insect and bird life in the area that resulted from the removal of the invasive non-native trees. Data are discussed in a section below.

Australian pine

Introduction

Australian Pine is native to Australia, Southeast Asia and the south Pacific Islands. It was first brought to the United States beginning in the late 1880s, and was spreading in Florida by the turn of the century. [15] It was widely used as a windbreak, especially for citrus trees, and was planted in the mistaken belief that the trees could prevent erosion.

Two species and a possible hybrid of Australian pine are found in the Thousand Islands: *Casuarina equisetifolia* and *Casuarina glauca*. The Generic name *Casuarina* comes from the Malay word *kasuari*, their word for the cassowary, referring to the resemblance of the tree's "needles" to the Cassowary's plumage. The specific name *equisetifolia* is derived from the resemblance of the needles to horse hair, and *glauca* refers to a bluish waxy coating on the "needles." In spite of its common name, Australian pine is not a true pine; it is a flowering tree. The needles are actually branches with small leaves in whorls along segments. A true pine has no flowers and the needles are the leaves.

All species of the genus *Casuarina* are regulated in Florida. The Florida Department of Environmental Protection (FDEP) lists all "*Casuarina* spp." as *Class I Prohibited Aquatic Plants*. This makes it illegal to posses, collect, transport, cultivate, or import them without a permit from the Department (62C-52.001 FAC).

The Florida Exotic Pest Plant Council rates Australian pine as a *Category I* plant. This category is defined as an "invasive exotic that is altering native plant communities by displacing native species, changing community structures or ecological functions, or hybridizing with natives." [16] This definition relies on *scientifically documented ecological damage* caused by the plant in question. The research documenting the deleterious effects of Australian pine is robust.

These classifications do not come lightly. They reflect the grave concern biologists have over the ability of these trees to invade, degrade, and even completely replace natural systems. **People are free to debate the aesthetic merits of Australian pines, but the ecological damage the trees do to native communities is a well-established fact of science.** [17]

Australian pine has shallow roots that rarely penetrate very deep into the soil. Planted in many areas to prevent erosion, this tree actually increases erosion by eliminating native vegetation with deeper roots, or mangroves with roots that absorb wave energy. [18] Along shorelines invaded by Australian pine in the Thousand Islands the banks generally erode from beneath the roots until the tree falls over, at times causing a hazard to navigation for power boats.

[15] J. F. Morton. The Australian pine or beefwood (*Casuarina equisetifolia* L.), an invasive "weed" in Florida. Prod. Florida State Horticultural Soc, 1980

17: Closeup image of male flowers of *Casuarina glauca*. Note light bands, which are whorls of small leaves.

[16] Florida Exotic Pest Plant Council. Invasive plant list. 2011

[17] And to emphasize again the mission of EEL, only science should drive decisions concerning management of the TICA.

[18] R. W. Klukas. Exotic terrestrial plants in south Florida with emphasis on Australian pine (*Casuarina equisetifolia*). As cited in Austin, 1978. Technical Report, South Florida Water Management District, 1969. Everglades National Park, Homestead, FL

The shallow roots also make these trees prone to wind throw during storms. [19] Often the trees survive being blown over and can sprout photosynthetic branches from roots exposed to sunlight. This is an adaptation that favors these trees in frequently disturbed coastal areas.

[19] T. Digiamberardino. Changes in a south east Florida coastal ecosystem after elimination of *Casuarina equisetifolia*. Nova University, 1986

Figure 18: Side view of wind-thrown Australian pine. Note extremely shallow root depth. In addition to making these trees prone to wind throw, this growth habit allows them to invade soils with shallow water tables, invading ecologically important transitional habitats between shore and uplands used by many species for forage and reproduction.

The shallow root systems of these trees enable them to invade areas with shallow water tables, eliminating or severely compromising foraging and/or breeding habitats for many native animal species and by shading out grasses and sedges that feed birds, or plants with flowers that provide pollen for insects. This interference disrupts food webs and the movement of energy through the ecosystem.

Reproduction

There are two species of Australian pine in the Thousand Islands, along with a possible hybrid between the two. The species *Casuarina equisetifolia* has male and female flowers on the same tree, and reproduces primarily by seed. [20] This species is recognizable by its shorter, sparse “needles" and generally more bedraggled, open look to the foliage.

[20] R. P. Wunderlin and B. F. Hansen. *Guide to the vascular plants of Florida*. University Presses of Florida, Tampa, third edition, 2011

The other species, *Casuarina glauca*, has male and female flowers on separate plants, and only the male flowering plant is found in Florida. It reproduces vegetatively by sending underground runners from which sprout new trees. This is commonly known as suckering. [21] This species is recognizable by its shaggy look with long “needles." These two species might have hybridized, producing a suckering version with male and female flowers on the same tree. These hybrids are thought to possess a greater tolerance for cold weather.

[21] R. P. Wunderlin and B. F. Hansen. *Guide to the vascular plants of Florida*. University Presses of Florida, Tampa, third edition, 2011

Australian pine does not rely on living organisms for pollination. It casts its pollen to the wind. Known as anemophilous pollination, the taller the tree the more effectively the pollen is broadcast to the female flowers. Australian pine pollen can cause allergic reactions in people. [22]

The Australian pine seed has a membranous wing to aid its dispersal, which can be either by wind or in water. [23] No birds are known to use Australian pine seeds as a food source with the exception of migrating gold finches, which are not seen in the Thousand Islands. The seeds might be eaten by ants, including the non-native fire ant *Solenopsis invicta*. It is safe to conclude that these trees have no value as a food source to any species commonly found in the Thousand Islands, either as a native resident or migrant. Australian pine use by wildlife is simply as a perch by birds, which any tree can provide.

[22] S. C. Elfers. Element stewardship abstract for *Casuarina equisetifolia*: Report to the Nature Conservancy. Technical report, U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Fire Sciences Laboratory, Missoula, MT., 1988

[23] P. Binggeli. *Casuarina equisetifolia* l. (casuarinaceae), woody plant ecology. Webpage, 1997

Figure 19: Image of seeds from (left to right) carrotwood, Brazilian pepper, Australian pine, and melaleuca. All are found in the Thousand Islands.

Ecological impacts

Australian pine is very effective at controlling competition from other plants for substrate, light, and nutrients. When established it alters the physical characteristics, temperature, light regime, and chemistry of soils. These alterations drastically affect the native plants and animals beneath it, generally excluding them almost completely. It is unusual to see much of anything alive beneath stands of these trees.

The exact mechanism by which Australian pines eliminate native vegetation is not known. It is likely to be a combination of shade, “needles" preventing germination, and chemical. *Casuarina glauca* is thought to posses allelopathic properties. Allelopathy is a property possessed by some plants whereby they exude chemicals that inhibit germination or growth of

other species nearby. These chemicals can come from living and/or dead tissues.

The chemicals (known as tannins) that are leached from Australian pine “needles" are claimed to be carcinogenic, and can kill cattle that forage on them. [24] Additionally, these chemicals find their way into the lagoon where their effect on native organisms is unknown. Australian pines are known to decrease soil pH, which has a dramatic effect on the capacity of the soil to retain nutrients. [25]

Terrestrial vegetation is a significant source of dissolved organic compounds that end up in the lagoon via transport by rain water seeping through dead leaves and the soil. [26] This is a major energy source that fuels the base of many trophic pathways (commonly called a “food web") in the lagoon. This material is used by many forms of bacteria. The bacteria are eaten by larger organisms and so on. Very little living plant biomass is consumed in this system (known as a detrital system). Chemicals from *Casuarina equisetifolia* have been found to kill some kinds of bacteria. [27] The effect of dissolved organic carbon compounds originating from Australian pine on lagoon organisms is almost completely unknown, but worthy of study and precaution in light of its carcinogenic effects.

[24] S. C. Elfers. Element stewardship abstract for *Casuarina equisetifolia*: Report to the Nature Conservancy. Technical report, U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Fire Sciences Laboratory, Missoula, MT., 1988

[25] D. A. Ussiri, R. Lal, and P. A. Jacinthe. Soil properties and carbon sequestration of afforested pastures in reclaimed mine soils of ohio. *Soil Sci Soc Am J*, 70:1797–1806, 2006

[26] W. E. Odum and C. C. McIvor. *Ecosystems of Florida*, chapter Mangorves, pages 517–548. University of Central Florida Press, Orlando, 1990

[27] R. Ashan, M. Islam, E. Haque, and A. Mossaddik. In vitro antibacterial screening and toxicity study of some different medicinal plants. *World Journal of Agricultural Sciences*, 5(5):617–621, 2009

Figure 20: Aerial view of tannin-stained seepage water from mangroves in an impoundment. Note different color compared to lagoon water. Tannins and other forms of dissolved organic carbon are a natural part of the Indian River Lagoon; native species evolved exposed to these chemicals. The effects of non-native dissolved organic carbon is unknown.

Australian pine has the ability to fix soil nitrogen at rates comparable to nodulated legumes. This explains the capacity of Australian pine to occupy nitrogen-poor sites. [28] This allows these trees to grow densely and quickly. The dense growth habit of Australian pine reduces light falling on the ground, and the high litter fall prevents germination of seeds. The ground level beneath stands of these trees is often utterly devoid of vegetation and any animals except for a few arthropods such as ants or spiders. The ground below these trees becomes ecologically sterile; the carpet of “needles" can become more than ten centimeters deep.

[28] B. H. Ng. The effects of salinity on growth, nodulation and nitrogen fixation of *Casuarina equisetifolia*. *Plant and Soil*, 103(1):123–125, 1987

Figure 21: View of “needle cast" beneath Australian pine in the Thousand Islands. This carpet of needles leaches chemicals and prevents any native seeds that fall on it from touching mineral soil, thus preventing them from germinating. Additionally, shade from the canopy helps to exclude other species from growing beneath the trees, eliminating competition for resources. This provides habitat for virtually no native plant or animal. It can be thought of as the ecological equivalent of a shaded parking lot.

Australian pine destroys nesting habitat for many protected species such as sea turtles, least terns, and crocodiles. These trees change the profile of dunes, making them steeper and horizontally compressed. [29] Remember, allowing Australian pine to remain anywhere provides a source population for dispersal elsewhere, including areas where resources have been spent to remove them.

Australian pine is known to exclude the gopher tortoise (*Gopherus polyphemus*) by making burrow excavation too difficult. [30] It is reasonable to conclude that Australian pine negatively impacts nesting habitat needed by the diamondback terrapin (*Malaclemys terrapin*) in a similar manner, making successful nesting impossible. The terrapin is a unique species unfortunately thought to be in serious decline locally. The Thousand Islands seem to be a local “stronghold" for this species and terrapins need all the nesting habitat they can get.

Mazzotti, Ostrenko, & Smith [31] studied the effects of Australian pine on small mammals and found that these trees effectively eliminated breeding animals from the landscape. The entire population demonstrated a strong preference for native vegetation. This finding is especially important because small mammals are a vital link between plants and predatory animals in ecosystem-level energy pathways. This systematic degradation of upper-trophic level biodiversity (i.e., predatory animals with backbones such as birds and mammals) is a major reason these trees are seen as having no place in a Florida landscape.

[29] R. F. Doren and D. T. Jones. *Strangers in paradise: impact and management of nonindigenous species in Florida*, chapter Management in Everglades National Park, pages 275–286. Island Press, Washington D.C., 1997

[30] R. W. Klukas. Exotic terrestrial plants in south Florida with emphasis on Australian pine (*Casuarina equisetifolia*). As cited in Austin, 1978. Technical Report, South Florida Water Management District, 1969. Everglades National Park, Homestead, FL

[31] F. J. Mazzotti, W. Ostrenko, and T. A. Smith. Effects of the exotic plants *Melaleuca quinquenervia* and *Casuarina equisetifolia* on small mammal populations in the eastern Florida Everglades. *Florida Scientist*, 44(2):65–71, 1981

North Crawford Island research

North Crawford Island was previously infested on its east end with Australian pine. In March 2007, I initiated long-term vegetation monitoring with permanent transects, as seen in the image below. The purpose of the research was to track changes in vegetation after removal of the Australian pines and Brazilian pepper.

Figure 22: Aerial image of north Crawford Island showing approximate location of vegetation monitoring transect.

The process is deceptively simply. One simply stretches a measuring tape between fixed points along the transect. The transect points have been set with a differentially-corrected GPS system with sub-meter accuracy. One then uses a long rule with a leveling bubble to measure how much of the tape is intercepted by various species of plants in a given height class.

Figure 23: Image of north Crawford Island showing tape along vegetation monitoring transect.

When the data are collected, the total distance that each species overlaps the tape in each class is calculated, and then divided by the total length of the tape to produce a percent cover value. This value can then be plotted in any number of ways. See figure caption for description. These values can be compared before and after removal of the trees, through time to monitor changes, or any treatment we wish to apply in an experiment.

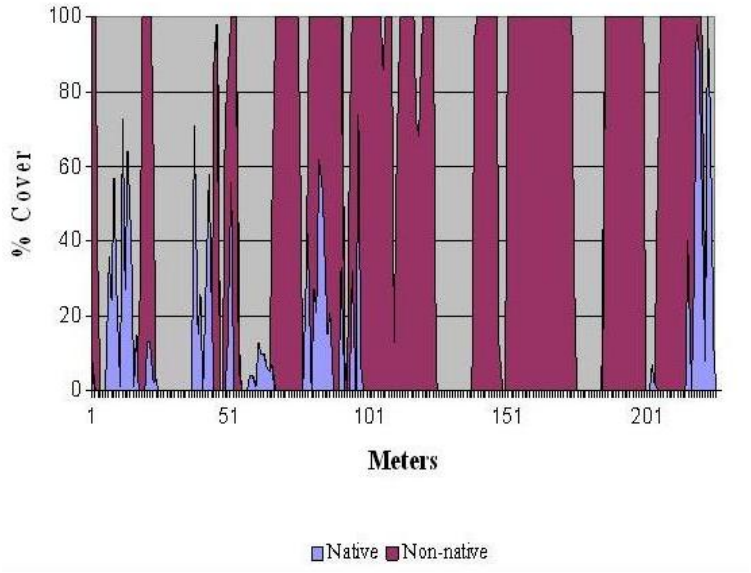

Figure 24: North Crawford line intercept data, transect 1, March 2007. This figure depicts the relationship between native shrubs (shown in blue) and Brazilian pepper and Australian pine (shown in red) for each meter. Transect length is approximately 230 meters. Some areas are bare. The central half of the transect is completely devoid of native vegetation, completely dominated by Australian pine.

The section of the transect between about 100 and 200 meters in the graph was dominated by Australian pine in 2007. This segment now supports a far more diverse plant community, comprising over 30 native species. [32] In turn this plant community now supports more wildlife. This is *why* the islands in the TICA were acquired — to promote biological diversity. The result of restoration can be seen in the figure below.

[32] T. J. Kozusko and D. S. Taylor. Unpublished vegetation study on crawford island in the Thousand Islands. 2011

Figure 25: North Crawford area formerly dominated by Australian pine. The area has far greater species diversity and includes the endemic coastal dune sandmat (*Chamaesyce cumulicola*), a state-listed endangered species. Again, this is why this property was acquired: to promote biological diversity. The recruitment of an endangered plant species into an area once dominated by Australian pine is yet more evidence why these trees must be removed.

The Costs

Too often the opinions of people with no credentials — or worse, conflicts of interest — are given equal weight to the opinions of subject matter experts. Imagine how this situation would play out in the construction of the country's infrastructure, if, for example, people who did not like the way a particular bridge made them feel had the ability to present their versions of engineering reality equally to those of the design engineers. How would you like to drive over that bridge? [33]

One mistake often made by people whenever the subject of removing Australian pines comes up is to refuse to consider how those trees prevent native productivity and diversity by their very existence. Let us imagine an island. It was previously slated for development and is covered by dredge spoil from the construction of an adjacent canal in 1958.

Upon this island is a nearly monotypic [34] stand of Australian pine. The area has come into public ownership as conservation land with passive recreation as a secondary use. We are the land managers. How should we proceed? If money were no object it is easy. Bulldoze the trees into a pile and burn them to a fine ash. Then bulldoze the island back into the canal to restore the natural water table and lagoon depth. But this will never happen; money is always an object.

Further limitations exist. We do not really have a natural analog to which to compare this island when designing a restoration target. But we do know which native species can live on it due to over 50 years of recruitment elsewhere in the area. The native plant species found in other areas support a diverse and numerous arthropod fauna (bugs), and the plants' fruits feed neotropical migratory birds as their energy reserves need replenishment on their route to South America and back. Fringing mangroves provide erosion control. Open areas provide sunny patches for grasses and forbs, breeding areas for diamondback terrapins, and forage for formerly common ground doves and six-lined racerunners.

We know that Australian pine provides none of these ecosystem services, and we know that they actually exclude many of the very species the land was acquired to protect. Yet a small misinformed group of people clamor to "save" the trees. They talk about about the shade, the beautiful sound of the wind in the needles. They demand — and receive — equal time given to their concerns in all manner of public and professional discourse, in spite of the fact that their demands are contrary to the stated purpose of the acquisition, and scientifically-defensible land management. How do we proceed so as to meet the management objectives?

Every action taken in an ecosystem has multiple results. This is known as "The First Law of Ecology." The interconnectedness of nature ensures that perturbations can be felt well away from the initial action, with unforeseen results. [35] We must ensure that it is understood by all that the land

[33] Excessive involvement of the lay public in the details of land management does not cause danger as such a bridge would. But the waste of time and money, and the compromised outcome of the process makes the analogy valid.

[34] Meaning Australian pine and almost nothing else.

Figure 26: The fruits of this native stopper shrub feed wildlife.

[35] For example, source reduction mosquito control. It has probably contributed to reduction in diamondback terrapins.

was acquired primarily for conservation. Conservation has a definition that is relevant to native species only. We must make people understand that leaving Australian pines in place is in conflict with the stated purpose of the acquisition, and that such an action will have many impacts to wildlife elsewhere.

There is a quote, usually attributed to Einstein, that not everything that counts can be counted. Let us imagine the island has been restored and no Australian pines remain. That island now provides many ecosystem services that it previously did not, and it supports some number of native plants and animals that it previously did not. It would take much effort to calculate a reasonable estimate for the increase in each species that resulted from removal of the Australian pines. But the actual number for each species is a trivial matter. We know from previous studies that removing these trees will have a positive impact on native species. This is an established fact of science.

How many cedar waxwings will be able to feed on fruits of the wax myrtle that now grow where the Australian pines had been? Beats me, but with the Australian pines there none could. Removing the trees improved the habitat, which supports biological diversity. We cannot know the exact number, but we know it increased. That is enough to justify the removal.

And there is another conceptual step we need to take. Rather than simply imagine how many plants and animals can be supported by removing the Australian pines, we must also discuss the *ecological cost* associated with demands that the Australian pines be allowed to remain.

This cost is ethically analogous to a *Take*. [36] Why is it illegal to cast light on the beach at night during sea turtle nesting season? You are not hurting the turtles. Or are you? *It is illegal because you are preventing successful reproduction, which is functionally equivalent to reducing their numbers.*

So what is the effective difference between allowing Australian pines to remain in conservation lands and in simply going to a conservation land and killing some equivalent number of native species? There isn't any. The acts are functionally equivalent; both result in reduction of numbers. This is the exact opposite of the intended purpose of the TICA. A decision to leave Category I non-natives on conservation land is destructive to the very species the property was acquired to protect.

I'm on solid ground here. [37] In fact, I would argue that without allocating resources (which neither Cocoa Beach nor EEL has) to monitor the ecological effects, there is no way to ensure that camping — even without Australian pines — is passive recreation. I've seen the garbage these people leave behind, and the damage they do to vegetation. Add Australian pine and it is simply incompatible with the management plan and EEL mission. These are the points we must make to those who think Australian pines "belong" in the TICA. Leaving them there is incompatible with the acquisition and management of the land.

[36] "Take" is defined in the Endangered Species Act as any action or attempted action that threatens or harms a protected species, including habitat modification. See for example, the Supreme Court Case Babbitt v. Sweet Home Chapter of Communities for a Great Oregon.

[37] Let us not ignore the question of *liability*. Camping has not proved to be passive recreation in the Thousand Islands. If you encourage camping and someone gets hurt, and your fire department can't get help to them in time …

Comments on North Thousand Islands Management Plan

Summary: [38]

- Ecological restoration and landscaping are two different endeavors.
- Removal of invasive, non-native plant species is not a one-time action.
- Phased removal of invasive non-native vegetation wastes resources by duplicating mobilization/demobilization costs.
- Planting trees to lend a vertical aesthetic to an area where Australian pine has been removed is a waste of time and resources.
- Open areas of bare sand are essential habitat to many organisms, and should be encouraged.

[38] This is given in abridged form for information purposes. My comments should be in the public record already.

Restoration

Ecological restoration and landscaping are two different endeavors. When done correctly, the former improves ecological functions, ecosystem services, and increases the abundance and diversity of species. The latter, usually constrained by taste rather than science, might improve an aesthetic appeal, and might or might not help ecosystem function. Removal of invasive non-native plants is based on ecological restoration, not landscaping.

It is unlikely that plants chosen for aesthetic appeal would have a significantly positive impact on ecosystem restoration compared to natural recruitment, particularly when species not naturally occurring in the Thousand Islands are chosen. Nature has given us 40–50 years of natural recruitment and succession on spoil islands. Let it guide you.

Removal of invasives

Removal of invasive, non-native plant species is not a one-time action.[39] It is a continuing aspect of land management, and to be successful it *must be science-driven*. Funds for follow-up treatment must be allocated. During the first year of a study I conducted over two years on north Crawford I encountered just over 7% cover of recurring Australian pine and Brazilian pepper. The following year I encountered 5% cover of these plants. The fact that the number went down is misleading — I pulled every non-native I encountered in 2011. The 5% cover had sprouted *entirely* in the year between sampling. That is substantial recruitment and must be planned for.

[39] To return to our bridge analogy, it is like elected officials installing infrastructure but making no plans to maintain it.

Phased removal

Phased removal of invasive non-native vegetation wastes scarce resources by duplicating mobilization/demobilization costs. In today's climate of shrinking budgets, it is unwise to add substantial costs to non-native vegetation removal by "taking the band-aid off slowly," especially when it goes against the scientific consensus.

The longer those plants remain, the longer they are reproducing, vegetatively and sexually. They add to below-ground biomass, making sprouting more likely, and they add to the seed bank. It is a simple matter of fact that invasive non-natives suppress native species — that is the very definition of invasive! The longer these plants are allowed to remain, the longer the species diversity and abundance of native plants and animals are suppressed. In the final analysis, what exactly is the difference between suppressing abundance of native species by allowing invasive non-natives to remain, and by simply killing native species?

If a stand of *Casuarina glauca* only were to be left on one section of the north islands referred to as "scout island" for camping, they could also be used as an educational tool to demonstrate how damaging they are to our native ecosystems. I would support that use and be glad to help with educational information. But that support is limited to one area in the north islands, and only for the non-seeding species.

Planting

Planting trees to lend a vertical aesthetic to an area where Australian pine has been removed is really a waste of time and resources. In little over a single growing season trees planted at Crawford Island in TICA were utterly overwhelmed by natural recruitment, both in number and coverage. After the second year height was even overwhelmed.

In fall of 2011 and again in 2012, I censused all trees and shrubs in a 0.25 hectare study area on north Crawford Island. One hundred two planted trees and shrubs were encountered in 2011, of which only 87 were alive. There was significant mortality. For example, 40% of the slash pine (a species not previously found in the Thousand Islands, and with, no business being there) had died. Seven of 15 large cabbage palms had died. Overall mortality was 14.7% in just one growing season.

Meanwhile, 248 native shrubs and trees at least one meter tall had recruited into the same area, versus the 83 planted that were at least one meter tall. The following year (2012) I counted 479 native recruited shrubs and trees at least one meter tall, compared to just 67 remaining from those planted.

In other words, native recruitment out-performed planting by nearly an order of magnitude after just one growing season. Even setting aside the wasted resources from mortality, in one growing season planted trees

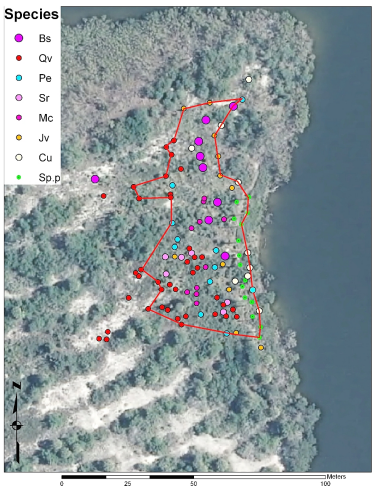

Figure 27: GIS map of study area polygon on north Crawford Island. Imagery date is 2012. The position of each planted shrub was recorded with differentially-corrected GPS. Key: Bs = gumbo-limbo, Qv = live oak, Pe = slash pine, Sr = palmetto, Mc = wax myrtle, Jv = red cedar, Cu = sea grape, Sp = cabbage palm. Each naturally recruited shrub within this polygon was also counted in 2011 and 2012. In addition, the GIS was used to generate random points, which were navigated to in the field for point-intercept sampling of non-woody vegetation.

were almost invisible from the water adjacent to the area; they were blotted out by the plants that had moved in all by themselves. I understand that there is some public opposition, and it involves that first growing season. I'm happy to be the lightning rod and take on that opposition with public education for you, especially with this dataset.

In 2011, 95 invasive non-natives had recruited in the study area. All were pulled. In the fall 2012 sampling another 35 had recruited. There is no walking away from treating exotic plants; it goes on and on. Welcome to the real world of land management. Continued recruitment into this area by invasive non-native species demonstrates a recurring need for follow-up herbicide treatments, and scarce resources should be put into this effort rather than be spent on gardening.

And if planting must be done, [40] better consideration should be given to the ecological context into which the plants are being placed. For example, what role does a slash pine play amid mangroves? None. What role does an oak play? Perhaps we should begin a list of all the critters found in mangrove islands that eat acorns. I am not aware of any, apart from more adventurous squirrels. If you are thinking oaks and slash pines provide nesting area and perches for birds, those services are provided by *trees*. Choose plants that will feed neotropical migrants with fruits. There are many appropriate species already found in the Thousand Islands. Planting trees based only on what you think will look nice is an affront to the concept of land management.

[40] Which might be an opportunity to gain some information if done in a better way than was the case on north Crawford. It would be interesting to plant some of the tropical hammock species already found in the Thousand Islands in clusters to see if hammocks might be easier to establish that way.

Open areas

Open areas of bare sand are essential habitat to many organisms, and should be encouraged. Formerly common species such as the ground dove and the six-lined racerunner depend on bare sand to forage for food. The diamondback terrapin requires open sandy areas in which to lay its eggs. In lower areas bare sediment supports fiddler crabs.

Elimination of bare sand hurts these species, and in turn decouples terrestrial and marine food webs. That is part of why many of these species are so uncommon now — as a society we seem to have an almost pathological abhorrence of bare sand or any place not covered by trees. This is an unfortunate example of ecological chauvinism that must be overcome. Or if it is not, at least we should be honest and acknowledge that when we preserve natural areas we do so for no reason other than our own values. That is not science-based land management; it is landscaping.

Closing Thoughts

It is worth pointing out that the Environmentally Endangered Lands Program, trusted by us to manage the TICA is not, and never was intended to be a landscaping program. Its stated mission is “Protecting and Preserving Biological Diversity Through Responsible Stewardship of Brevard County’s Natural Resources." Responsible stewardship is further defined as being “. . . guided by scientific principles for conservation and the best available practices for resources, stewardship and ecosystem management." It is difficult to fathom how the willful protection of any non-native species, be it stray cat, Brazilian pepper, or Australian pine, could possibly be a part of that mission.

Many biologists, myself included, view non-native species as an even bigger threat to the ecological diversity of Florida than development because these invaders threaten lands already protected from the bulldozer. The State is currently involved in a pitched battle against species such as Australian pine, spending millions of dollars trying to bring them under control. State funds were given toward the acquisition of these islands; it is simply unreasonable to expect anyone to sanction the protection of these trees.

No one likes change. And even though it will be gradual, as these trees are removed the islands will look different. But we must not see this in the darkness of something that has been lost, rather we should think of it in the light of what has been gained.

The next time you look at a stand of Australian pines I challenge you to see them not as stately trees swaying gently in the sea breeze, but as trespassers that are taking something from us. I challenge you to understand that the pelicans resting on branches hanging over the water will find other places to rest — just as they did for thousands of years before these trees were brought to Florida.

I challenge you to consider all the native species, the ones we are trying to protect, that will be able to reclaim the land currently held against its will by these trees. And I challenge you not to be selfish about how you feel the land should look, but rather to accept the removal of these trees as a science-based act of ecological healing, fulfilling the EEL mission. By every contextually relevant definition of the word “right," this is the *right thing to do*.

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