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ESSAY

Friends or Foes? The Problem of South Florida's Invasive Mangroves

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I. INTRODUCTION

As global temperatures warm and seas begin to rise, all eyes are turning to South Florida. What is this low-lying coastal region going to do about climate change? In particular, the Miami-Dade metropolitan area has been widely referred to as "ground zero" for climate change[1] largely because the state's geography, population, and resources make it vulnerable to flooding, sea level rise, erosion, storms, ecological destruction, and many other threats.[2] The City of Miami Beach has already undertaken adaptive measures to address current impacts of sea-level rise by installing flood pumps[3]

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1. Peter Howard, *Miami Takes Center Stage as 'Ground Zero' for Climate Change*, U. MIAMI: NEWS & EVENTS (Nov. 13, 2015), http://news.miami.edu/stories/2015/11/miami-takes-center-stage-as-ground-zero-for-climate-change.html [http://perma.cc/MG8E-PJFA].

2. *See generally* Giselle Peruyera, *A Future Submerged: Implications of Sea Level Rise for South Florida*, 8 FLA. A & M U. L. REV. 297 (2013) (examining the role of South Florida's environmental policies in combating and adapting to climate change risks).

3. Joey Flechas, *Miami Beach Shows Off New Anti-Flooding Pumps*, MIAMI HERALD (Sept. 17, 2014, 5:21 PM), http://www.miamiherald.com/news/local/

and elevating roads.[4] The City has even contemplated creating mandatory green spaces so as to reduce impervious surface area and allow for drainage.[5] These measures are viewed as progressive, even preemptive, in a state where the phrase "climate change" is so politicized that it has been banned from use by the highest-ranking state officials.[6]

However, climate change impacts in the region pose a very real and substantial threat to both the financial and human capital in South Florida. In Miami-Dade County alone, more than $345 billion and more than 2.6 million people are at risk due to climate change impacts such as flooding and sea-level rise.[7] While adaptation and planning play an important role in preparing South Florida for the "long slow flood,"[8] organizations and governments are turning to more natural solutions. For example, a recent partnership between The Nature Conservancy and Miami-Dade County seeks to address climate change impacts in South Florida through adoption of "nature-based infrastructure solutions" such as natural mangrove shorelines, coral reefs, wetlands, and dunes to "absorb floodwaters, lessen wave energy and protect coastal residents and assets from the damages caused by storms."[9]

community/miami-dade/miami-beach/article2142718.html [https://perma.cc/CE8S-UKE2].

4. Joey Flechas, *Miami Beach Wants to Fast-Track Work to Battle Sea-Level Rise*, MIAMI HERALD (Mar. 11, 2016, 8:27 PM), http://www.miamiherald.com/news/local/community/miami-dade/miami-beach/article65577892.html [http://perma.cc/3EQJ-WZGH].

5. *See generally* Debora Lima, *Miami Beach Commission Scraps Most Provisions of Single-Family Home Ordinance*, MIAMI HERALD (Jan. 13, 2016, 10:16 PM), http://www.miamiherald.com/news/local/community/miami-dade/miami-beach/article54607275.html [http://perma.cc/79XK-TGYE] (discussing the Commission's reasoning behind setback ordinance, including the conservation of green space to absorb rainwater).

6. Tristam Kortem, *In Florida, Officials Ban Term 'Climate Change'*, MIAMI HERALD (Mar. 8, 2015, 4:00 AM), http://www.miamiherald.com/news/state/florida/article12983720.html [http://perma.cc/UYC9-GTNU].

7. *The Nature Conservancy Looks to Address South Florida Climate, Catastrophe Risks*, INS. J. (Apr. 11, 2016), http://www.insurancejournal.com/news/southeast/2016/04/11/404765.htm [http://perma.cc/F2KA-E6X9].

8. Spenser Solis, *PIEC Seeks Positive Change for Florida's Environmental Woes*, UF L. ENEWS, https://www.law.ufl.edu/enews/042009/piec.shtml [http://perma.cc/9DVM-6LFM].

9. *The Nature Conservancy Looks to Address South Florida Climate, Catastrophe Risks*, *supra* note 7.

It is well accepted within the scientific community that of these nature-based solutions, mangroves[10] provide the best form of shoreline protection from wave action.[11] In fact, mature mangrove forests in some locations have been found to reduce wave impact by as much as 20 percent.[12] In Florida, the estimated 469,000 acres of mangrove forests not only protect coastal regions of the state from wave action, but also provide other valuable ecosystem services such as sediment stabilization, nutrient cycling, carbon sequestration, and habitat for marine life.[13] In fact, mangroves are of such importance in Florida that they have received legal protection from the state in order to preserve these vital resources that are valuable to the environment and the economy.[14] In an attempt to foster mangrove growth and to reap the benefits from these ecosystems, many areas of South Florida are undergoing restoration projects to revert shorelines and coastal areas back to their mangrove "roots."[15] These projects evidence how scientific, legal, and political disciplines have taken a multi-disciplinary approach to protecting mangroves. In fact, mangroves are so valuable and effective in stabilizing shorelines, that there is a surge of interest from architects and engineering firms to

10. Mangroves are trees or shrubs that live in the coastal intertidal zone. *What is a "Mangrove" Forest?*, NAT'L OCEAN SERV., NAT'L OCEANIC ATMOSPHERIC ADMIN., http://oceanservice.noaa.gov/facts/mangroves.html [http://perma.cc/3MKY-LAG6].

11. Katherine C. Ewel et al., *Different Kinds of Mangrove Forests Provide Different Goods and Services*, 7 GLOBAL ECOLOGY & BIOGEOGRAPHY LETTERS 83 (1998).

12. Yoshihiro Mazda et al., *Mangroves as a Coastal Protection from Waves in the Tong King Delta, Vietnam*, MANGROVES & SALT MARSHES 127 (1997).

13. *What are Mangroves?*, FLA. DEP'T. OF ENVTL. PROT., http://www.dep.state.fl.us/coastal/habitats/mangroves.htm [http://perma.cc/H8ZY-GZYF] (last updated Feb. 12, 2015). *See generally* Felicia C. Coleman & Laura E. Petes, *Getting into Hot Water: Ecological Effects of Climate Change in Marine Environments*, 17 SE. ENVTL. L.J. 337, 343-45 (2009) (discussing how temperature changes, sea level rise, ocean acidification, and other environmental changes caused by climate change affect marine organisms).

14. *See generally* 1996 Mangrove Trimming and Preservation Act, FLA. STAT. §§ 403.9321-403.9333 (1996) (outlining various provisions pertaining to mangroves); Ericson P. Kimbel, *The Ecological and Economic Failures of Florida's Mangrove Regulatory Scheme*, 5 OCEAN & COASTAL L.J. 23 (2000) (discussing use and non-use values of mangrove ecosystems).

15. *See Mangrove Restoration,* FLA. INT'L SCH. OF ENV'T, ARTS & SOC'Y, https://seas.fiu.edu/outreach/community-events/mangrove-restoration [https://perma.cc/H9M5-AL4X].

incorporate mangroves with man-made structures (e.g., seawalls) to enhance the already natural capacity of this ecosystem to control erosion.[16] Some of the most striking examples of this concept include the incorporation of mangroves into urban landscapes on Miami Beach to protect the City against impending sea levels[17] and the construction of prototype hybrid floating concrete and natural mangrove structures in Colombia to mitigate erosion on islands and promote mangrove recruitment.[18]

A recent global review on the impacts of climate change on mangroves concluded that different regions will experience varying degrees of impacts due to the variability of expected changes in climate (shifts in precipitation, frequency and intensity of storms, droughts, sea level rise, change of ocean currents, increases in CO_2 concentrations, etc.) and the variety of types and mangrove assemblages growing in these regions, including different species composition of mangrove forests.[19] In North America and the Caribbean, these changes are dependent upon a predicted higher frequency (and intensity) of tropical storms, sea level rise, changes in patterns of precipitation, and higher temperatures. Located at the land-sea interface, mangroves in this region are expected to expand their ranges poleward (towards North Florida), or migrate into other coastal ecosystems (e.g., the Everglades), provided no natural or urban center barriers are present to prevent this expansion. If rains increase, as is anticipated, along the United States-Mexico border, mangroves may likely begin to thrive in places currently occupied by

16. *See generally* David Fleshler, *Panels of Fake Mangroves May Transform Florida's Seawalls*, SUN SENTINEL (Dec. 22, 2016, 10:03 AM), http://www.sun-sentinel.com/local/broward/fl-fake-mangroves-20161223-story.html [http://perma.cc/8T22-QN7Y].

17. Jessica Weiss, *Mangroves, Stilts, and Canals Might Just Save South Beach from Rising Seas,* MIAMI NEW TIMES (Nov. 20, 2015, 8:00 AM), http://www.miaminewtimes.com/news/mangroves-stilts-and-canals-might-just-save-south-beach-from-rising-seas-8062542 [https://perma.cc/XPC9-RMLR].

18. Natalina Lopez, *CEMEX + Aptum Architecture's Floating Concrete Structures Act as Mangroves for Shorelines* (Oct. 29, 2016), http://www.archdaily.com/798241/aptum-architectures-floating-concrete-act-as-mangroves-for-shorelines [https://perma.cc/KM83-SZTG].

19. Raymond D. Ward et al*., Impacts of Climate Change on Mangrove Ecosystems: A Region by Region Overview,* 2 ECOSYSTEM HEALTH AND MGMT. 1 (2016).

unvegetated salt flats.[20] However, a lack of rain may also be of benefit in areas such as Louisiana where marsh diebacks have been linked to droughts, which directly increases the likelihood of mangrove migrations into these ecosystems.[21]

Given the services that mangroves provide and the legal protections that mangroves receive, it is shocking to discover that their future existence may be compromised or threatened. Certainly, the greatest threats to mangroves in Florida are from direct and indirect human impacts of development, including pollution and habitat destruction.[22] Mangroves may also be naturally damaged and destroyed from disturbance events such as tropical storms and hurricanes.[23] However, a new threat to native mangroves has recently emerged: the introduction of invasive mangrove species. These non-native species may threaten the ecosystem dynamics of mangrove forests and may alter the natural coastal landscape of South Florida unless eradicated.

II. MANGROVES: THE LAW OF THE LAND

A. Legal Landscape

For many, South Florida in the late 1800s and early 1900s presented two realities. The region was either considered a veritable wasteland of swamp where death by mosquito or heat stroke was nearly certain, or a savvy investment opportunity ripe with tourism potential.[24] Public policy favored the latter and thus, development of the coastal areas quickly became the norm. Cypress swamps, wetlands, and mangrove forests were quickly transformed into farmland, residences, and hotels.[25] The odorous mangrove forests were viewed as barriers to development and

20. *See generally* Michael J. Osland et al., *Freshwater Availability and Coastal Wetland Foundation Species: Ecological Transitions Along a Rainfall Gradient,* 95 ECOLOGY 2789 (2014).

21. Karen L. McKee et al., *Acute Salt Marsh Dieback in the Mississippi River Deltaic Plain: A Drought-Induced Phenomenon?*, 13 GLOBAL ECOLOGY & BIOGEOGRAPHY 65 (2004).

22. *What are Mangroves?*, *supra* note 13.

23. *Id.*

24. MICHAEL GRUNWALD, THE SWAMP: THE EVERGLADES, FLORIDA, AND THE POLITICS OF PARADISE 81-97 (2007).

25. *Id.*

occupants of valuable waterfront property.[26] As such, the mucky forests were cleared, cut, and drained, taking the mosquitos and smell of rotting detritus with them.[27]

This policy of rampant coastal development at the expense of mangrove forests was supported until 1984, when the Florida Legislature enacted its first mangrove statutes.[28] The first mangrove protection statutes in Florida coincided with publication of a study by William E. Odum that confirmed the essential role mangroves play in nutrient cycling.[29] Soon thereafter, the Florida Department of Environmental Regulation, now the Florida Department of Environmental Protection (FDEP), adopted the first mangrove protection rules.[30] The early 1990s marked a period of staunch opposition to the mangrove protection rules, which were seen as incredibly complex and confusing, particularly with regards to the sections that governed mangrove trimming.[31] In 1992, Nathanial Reed[32] and other riparian landowners petitioned for an administrative hearing on the rules to determine whether the mangrove trimming laws were valid.[33] As a result of this hearing, the mangrove rules were deemed an invalid exercise of

26. *Id.,* at 172.

27. *See Q: What Kind of Swamps Were Filled During the Development of Miami Beach?*, HIST. MIAMI (Nov. 13, 2008, 3:00 AM), http://miamiherald.typepad.com/make_miami_history_now/2008/11/q-what-kind-of.html [http://perma.cc/5L84-NFFD]; *Mangrove Forest Being Cut Down – Miami Beach, Florida*, FLA. MEMORY, https://www.floridamemory.com/items/show/27308 [http://perma.cc/W85K-WXZY].

28. Kellyalexis Fisher, *Man Let 'em Grow: The State of Florida Mangrove Laws*, 73 FLA. BAR J. 58 (1998).

29. *See* William E. Odum, *Dual-Gradient Concept of Detritus Transport and Processing in Estuaries*, 35 BULL. OF MARINE SCI. 510 (1984).

30. Fisher, *supra* note 28, at 58.

31. *Id.* The Mangrove Protection Rule was met with staunch criticism from riparian owners and developers who found the rule too restrictive. *See* James Phillips, *Mangroves Matter,* FLA. SPORTSMAN (May 16, 2011), http://www.floridasportsman.com/2011/05/16/confron_0502_mangroves/ [https://perma.cc/2G5N-RJ3S].

32. Nathanial Reed is widely considered to be one of the most influential environmentalists in the burgeoning history of the state of Florida. *See Honorary Membership Nomination Narrative: Nathaniel "Nat" Reed*, AM. SOC'Y OF LANDSCAPE ARCHITECTS, https://www.asla.org/uploadedFiles/CMS/About__Us/Honors_and_Awards/Honorary_Membership/2011_Honorary_Members_images/Reed.pdf [https://perma.cc/234V-U8NJ].

33. Fisher, *supra* note 28, at 58-59.

delegated legislative authority and were therefore declared invalid.[34]

Following this decision, the 1995 Mangrove Trimming and Preservation Act (MTPA, The Act) was passed, which revised and simplified the mangrove protection laws. The new Act reduced the amount of permitting and paperwork required for trimming mangroves, and in some cases, eliminated such requirements altogether.[35] The original 1995 Act had many opponents, which included many local governments, because it preempted local home rule and municipal permitting powers.[36] Environmental groups were also dismayed at the casual disregard for permitting and relaxed enforcement of mangrove trimming activities.[37] In 1996, the Florida Senate Natural Resources Committee took steps to put "[p]reservation [b]ack [i]nto the Act."[38] This "second wave" of mangrove legislation was supported by a 1992 scientific study by Snedaker et al., which found that mangrove mortality was linked to over-trimming.[39] As a result, the 1996 amendments to the Act tightened restrictions on mangrove trimming by regularly requiring permits, restoring home rule to local governments,[40] prohibiting the use of herbicides on mangroves, specifically outlining trimming standards,[41] and increasing fines for noncompliance.[42]

34. *Id.*

35. *Id.* at 59.

36. *Id.*

37. *Id.*

38. *Id.* at 60.

39. *See* Samuel C. Snedaker et al., *Recovery of a Mixed-Species Mangrove Forest in South Florida Following Canopy Removal*, 8 J. COASTAL RES. 919 (1992).

40. More recent cases have challenged local governments' ability to regulate mangroves and to enforce the Mangrove Act. *See* Jupiter v. Byrd Family Tr., 134 So. 3d 1098 (Fla. Dist. Ct. App. 2014) ("The Mangrove Act expressly preempts local regulations of mangroves and enforcement unless the local government receives delegation from DEP.").

41. *See* Kimbel, *supra* note 14, at 40-41.

> Generally, property owners may trim, without a permit, existing mangroves on their property of 10 feet or less in height to a height of not less than six feet from the substrate in maintenance or enhancement of their riparian right of view. If the landowner trims 5% or more of the mangrove to a height of six feet or less, the landowner must mitigate under Florida Statute section 403.9332.

Id.

42. Fisher, *supra* note 28, at 60.

III. TOO MUCH OF A GOOD THING: THE PROBLEM WITH INVASIVE MANGROVES

A. Native Mangroves in Florida

Worldwide, there are approximately 60 species of mangroves, with most of the species occurring in the Indo-Pacific region.[43] In the Western Hemisphere, there are approximately 10 species of mangroves.[44] In the State of Florida, there are three native true[45] mangroves: the red mangrove (*Rhizophora mangle*), the black mangrove (*Avicennia germinans*), and the white mangrove (*Laguncularia racemosa*).[46] Historically, mangrove distribution in Florida has extended along both the Atlantic Ocean and Gulf of Mexico coasts, as far north as the Ponce de Leon Inlet and Cedar Key, respectively.[47] However, recent studies suggest that mangroves may be expanding poleward as a result of climate change and fewer cold days in the year.[48] While a warming climate may increase the ranges and distributions of some mangrove species, it may also constrain those of others. In fact, increasing

43. F. Blasco et al., *Recent Advances in Mangrove Studies Using Remote Sensing Data*, 49 MAR. FRESHWATER RES. 287, 288 (1998).

44. *Id.*

45. True mangroves are defined by their strict fidelity to the mangrove environment. They only occur in mangrove forests and do not extend into terrestrial communities. True mangroves play a major role in the structure of the community and they have the ability to form pure stands. True mangroves have morphological specialization that adapts them to their environment including features such as aerial roots and vivipary of the embryo. Further, true mangroves have physiological mechanisms for salt exclusion so growth in sea water is possible. They have taxonomic isolation from terrestrial relatives at the generic level and often to the family or subfamily level. For the purposes of this article, the Buttonwood tree (*Conocarpus erectus*) is not a true mangrove, but is a mangrove associate species. *See* Liangmu Wang et al., *Differentiation Between True Mangroves and Mangrove Associates Based on Leaf Traits and Salt Contents*, J. PLANT ECOLOGY 1 (2010).

46. Odum et al., *The Ecology of the Mangroves of South Florida: A Community Profile*, U.S. FISH & WILDLIFE SERV. 2 (Jan. 1982).

47. *Id.*

48. *See* Kyle C. Cavanaugh et al., *Poleward Expansion of Mangroves is a Threshold Response to Decreased Frequency of Extreme Cold Events*, 111 PROC. NAT'L ACAD. SCI. 723 (2013). "Mangroves cannot tolerate extreme freezing temperatures and so are generally limited to tropical environments. However, climate change in the form of increasing temperatures has the potential to facilitate increases in mangrove abundance near tropical–temperate transition zones." *Id.*

global temperatures over the past century have had tangible impacts on a variety of plants that has resulted in an alteration of reproductive timing and an increase in the risk of loss of genetic diversity.[49]

The suggestion that the mangrove distribution in Florida is expanding because of a warming climate may be viewed as good news by coastal planners, resource managers, and local governments. More miles of mangrove coastline provide more protection from rising seas, powerful storms, and stronger wave action to coastal communities in South Florida.[50] In addition, more mangroves means more carbon sequestration. Mangroves have been found to store more carbon dioxide than their terrestrial relatives, making them an important "carbon sponge" to aid in abating our warming climate.[51] However, an increase in mangrove ranges may result in alternative and unanticipated impacts on the ecological stasis of South Florida's ecosystems. To date, such impacts on nutrient loading, bio-chemical composition of wetlands, biodiversity, and wildlife distribution have been virtually unstudied.[52] Further, such a change in ecological conditions opens the door to the growth non-native species, such as invasive mangrove species.

B. Invasive Mangroves in Florida

The introduction of non-native mangrove species to Florida began with Dr. David Fairchild, a world-renowned American botanist, plant collector, and international explorer.[53] He is credited with the collection, introduction, and propagation of many

49. Alejandro E. Camacho, *Assisted Migration: Redefining Nature and Natural Resource Law Under Climate Change*, 27 YALE J. ON REG. 171, 180-81 (2010).

50. *See* Jim Waymer, *Could Mangrove Northern Expansion Temper Global Warming?*, FLA. TODAY (Jan. 14, 2017, 11:04 AM), http://www.floridatoday.com/story/news/local/environment/2017/01/14/could-mangrove-northern-expansion-temper-global-warming/94736686/ [https://perma.cc/XLE7-VK44].

51. Jenny Staletovich, *Everglades Mangroves Might Hold Billion-Dollar Fix for Climate Change*, MIAMI HERALD (Nov. 25, 2016, 2:34 PM), http://www.miamiherald.com/news/local/environment/article117015083.html [https://perma.cc/WF9Y-XHAZ].

52. *Id.*

53. *Everglades Biographies: David Grandison Fairchild*, EVERGLADES DIG. LIBRS., http://everglades.fiu.edu/reclaim/bios/fairchild.htm [https://perma.cc/N8VH-962B].

plant species of economic and aesthetic value from the late 1800s to the mid-1900s.[54] In the 1940s, Fairchild traveled to Indonesia and collected a species of mangrove *Bruguiera gymnorrhiza* (*B. gymnorrhiza*).[55] He planted two specimens of this tree at his home in Coconut Grove, Florida – a location that has since been transformed into a botanical garden known as the Kampong.[56] Approximately thirty years later, at the Fairchild Tropical Botanic Garden (Fairchild Garden) located in nearby Coral Gables, Florida,[57] horticulturists planted a second non-native species of mangrove: *Lumnitzera racemosa* (*L. racemosa*).[58]

For decades, the two non-native mangrove species remained contained in their respective botanical gardens. However, each eventually "escaped" and have since naturalized and spread in and around the Miami-Dade County area.[59] The latter species, *L. racemosa*, is nearly indistinguishable from Florida's native white mangrove and was first found invading Matheson Hammock Park in 2008.[60] Fairchild Garden horticulturists had planted 14 specimens of *L. racemosa* in three locations between 1966 and 1971.[61] In 2009, only one of the original specimens remained, but the species had "aggressively spread, growing more densely than native mangroves".[62] By 2010, the invasion in Matheson Hammock had covered nearly 20 acres and approximately 20,000 *L. racemosa*

54. *Id.*

55. Jenny Staletovich, *The Mystery of South Florida's Runaway Mangroves*, MIAMI HERALD (Aug. 25, 2015, 11:41 PM), http://www.miamiherald.com/news/local/environment/article32404647.html [https://perma.cc/W27K-NT4R].

56. *Id.*

57. *See Mission & History,* FAIRCHILD TROPICAL BOTANIC GARDEN, http://www.fairchildgarden.org/about-fairchild/mission-history [https://perma.cc/S5KZ-GMUN].

58. Staletovich, *supra* note 55.

59. James W. Fourqurean et al., *Are Mangroves in the Tropical Atlantic Ripe for Invasion? Exotic Mangrove Trees in the Forests of South Florida*, 12 BIOLOGICAL INVASIONS 2509, 2517 (2009).

60. Staletovich, *supra* note 55; *see also* Jennifer Possley, The Long and Winding Road Toward Lumnitzera Eradication: Common Questions and Answers, 5 Everglades Coop. Invasive Species Mgmt. Area Newsl. 2-3 (July 2014), http://bugwoodcloud.org/mura/ECISMA/assets/File/Newsletter14/ECISM A _July2014_newsletter_WEB.pdf [https://perma.cc/3WMV-5P5G]. The authors presented about this issue at the Mangroves and Macrobenthos Meeting in July 2016. Their presentation poster is included with the online version of this article, which is available at: http://digitalcommons.pace.edu/PELR/vol34/iss2/6.

61. Staletovich, *supra* note 55.

62. *Id.*

plants were removed with the first eradication efforts.[63] In 2012, around 17,000 *L. racemosa* saplings were removed.[64] In 2014, approximately 7,500 saplings were removed and in 2015 only 1,380 saplings were removed from Matheson Hammock Park.[65] While it appears that the problem of the invasive *L. racemosa* is slowly being controlled, there is other disconcerting news. Fairchild Gardens held a plant sale in the 1970s where 14 specimens of *L. racemosa* were sold and, unfortunately, there is no record of where each specimen ended up.[66] Moreover, there is a bit of a biological mystery with the seeds of this species. Nearly six years after the last mature *L. racemosa* tree was uprooted, thousands of seeds are still being found in Matheson Hammock Park and scientists are unsure where they are coming from.[67]

We see a similar story line for *B. gymnorrhiza*. Nearly 90 viable saplings were found in the Kampong botanical garden, motivating the decision to remove the last remaining mature tree.[68] However, six months after the last tree was removed, dozens of new saplings continued to appear. Further investigation by Miami-Dade Coastal Resources revealed that a mature *B. gymnorrhiza* had established nearly half a mile from the Kampong.[69] Scientists suggest that the Kampong trees had been releasing propagules, floating mangrove seeds, into nearby water bodies for over half a century.[70]

South Florida is a hotbed for invasive species, with over 500 non-native species of fish and wildlife and over 1.5 million acres impacted by non-native plants.[71] In fact, South Florida is home to more non-native species than any other region in the United States.[72] This unbridled spread is due in part to the appealing

63. Staletovich, *supra* note 55.
64. *Id.*
65. *Id.*
66. *Id.*
67. *Id.*
68. *Id.*
69. *Id.*
70. *Id.*
71. *Florida's Exotic Fish and Wildlife,* FLA. FISH & WILDLIFE CONSERVATION COMM'N, http://myfwc.com/wildlifehabitats/nonnatives/ [http://perma.cc/HN4R-7ERX].
72. *Vegetation and Exotic Control*, S. FLA. WATER MGMT. DIST., https://www.sfwmd.gov/our-work/vegetation [http://perma.cc/H2F8-6YX5].

subtropical climate of the region, which is ideal for the introduction, establishment, and spread of invasive species. In fact, exotic plant imports throughout Florida account for nearly three-fourths of all plant imports nationwide.[73] The management of those exotics that "escape" has a steep price tag – over $100 million per year.[74] As can be expected, exotic mangrove species enjoy the hospitable South Florida climate as much as the local residents. A 2009 study by Fourqurean et al. attributes the success of *L. racemosa* and *B. gymnorrhiza*, despite native competitors, to "the similar environments in tropical American and Indo-Pacific mangrove forests, the close taxonomic relationships between the invaders and native taxa, the species-depauperate flora of tropical American mangroves compared to the Indo-Pacific, and the prevalence of disturbance in the introduction sites."[75] Both species of invasive mangroves have extensive native ranges, broad environmental tolerances, and great dispersal abilities.[76] In fact, *B. gymnorrhiza* has the broadest natural range of all mangrove species worldwide, which suggests its establishment success in South Florida.[77]

According to the Fourqurean study, both species of invasive mangroves are able to adapt and thrive in a wide range of environmental conditions.[78] Further, they both have characteristics of aggressive growth rates and are self-compatible, that is, a single individual from either species has the ability to reproduce.[79] The study postulates that because *B. gymnorrhiza* at the Kampong was located in close proximity to a body of water, it is likely that the population of this species has expanded throughout Biscayne Bay due to the interconnectedness of the South Florida watershed.[80] However, *L. racemosa* has been confined to the mosquito ditches of Fairchild Gardens and

73. *Florida: Stopping the Spread of Invasive Species*, NATURE CONSERVANCY, http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/florida/howwework/combating-invasive-species-in-florida.xml [http://perma.cc/Y2U6-EZ3F].

74. *Id.*

75. Fourqurean et al., *supra* note 59, at 2518.

76. *Id.*

77. *Id.*

78. *Id.*

79. *Id.* at 2520-21.

80. *Id.*, at 2521.

Matheson Hammock, and therefore, it is unlikely that the outbreak has spread throughout the Miami area.[81] Researchers caution that one major hurricane event could change this confinement because *L. racemosa* has the ability to reproduce through wind dispersal.[82] The study warns of serious consequences to the spread of these invasive species, including direct impacts to nutrient cycling and food web structure.[83] As such, a precautionary approach to management is necessary to ensure that the entire region does not succumb to a non-native mangrove invasion.[84]

The Fourqurean et al. study serves as a delicate word of caution to policy makers and resource managers alike because invasions by non-native species can be extremely costly and bring forth other complex issues. For example, the melaleuca tree (*Melaleuca quinquenervia*), a non-native tree originally from Australia, has caused extensive damage to natural wetlands in Florida and has proved extremely difficult to eradicate.[85] Since its introduction to Manatee County in 1887 by the U.S. Army Corps of Engineers, the melaleuca tree has caused damage of upwards of $1.7 billion.[86]

Moreover, state practice has at best been "ill-defined" with regard to invasive species that also provide a beneficial purpose to human activities.[87] Doctor Sophie Riley discusses the relationship between invasive plant species and bio-fuels, highlighting the "human dimension" of regulating, or not regulating, invasive plants.[88] She notes that "[i]n many cases, disruption of, or interference with, *human* activities traditionally has been decisive as to whether an alien species is classified and regulated as an invasive alien species, irrespective of the harm that it is causing to

81. Fourqurean et al., *supra* note 59, at 2519.

82. *Id.*

83. *Id.* at 2521.

84. *Id.*

85. *See* Frank J. Mazzotti et al., *Ecological Consequences of Invasion by* Melaleuca quinquenervia *in South Florida Wetlands: Paradise Damaged, not Lost*, UNIV. OF FLA: IFAS EXTENSION (1997), http://edis.ifas.ufl.edu/uw123 [http://perma.cc/UX3K-XLDR].

86. Staletovich, *supra* note 55.

87. Sophie Riley, *A Weed by Any Other Name: Would the Rose Smell as Sweet if it Were a Threat to Biodiversity?*, 22 GEO. INT'L ENVTL. L. REV. 157, 159-62 (2009) (discussing how the classification of a species as "invasive" rests largely on that species' utility to humans).

88. *Id.*

biodiversity."[89] If human impacts, more specifically economic impacts, commonly drive regulation of invasive species, we must wonder at what point invasive mangroves will reach that threshold? Will a combination of economic and environmental costs trigger regulation, or, can preemptive action take place before impacts get worse?

IV. MUCH ADO ABOUT MANGROVES: LEGAL & MANAGEMENT FRAMEWORKS FOR INVASIVE MANGROVES

A. The Mangrove Trimming and Preservation Act

The Mangrove Trimming and Preservation Act has remained virtually unchanged since the 1996 amendments. The text of the Act specifically defines a mangrove as "any specimen of the species *Laguncularia racemosa* (white mangrove), *Rhizophora mangle* (red mangrove), or *Avicennia germinans* (black mangrove)."[90] The text of the Act has not been altered to reference the existence, let alone impact, of invasive mangrove species in Florida. From a textual, statutory interpretation standpoint, we should go no further. The Plain Meaning Rule[91] and the canon of *expressio unius*[92] suggest that because the statute specifically defines which mangrove species are under the jurisdiction of the Act, all other species of mangroves are not included for the purposes of protection and preservation. That is, invasive mangrove species are in no way protected under the MTPA.

89. *Id.* (emphasis added).

90. FLA. STAT. § 403.9325 (2015).

91. KATHARINE CLARK & MATTHEW CONNOLLY, THE WRITING CTR.: GEORGETOWN UNIV. LAW CTR., A GUIDE TO READING, INTERPRETING, AND APPLYING STATUTES (2006), https://www.law.georgetown.edu/academics/academicprograms/legal-writing-scholarship/writing-center/upload/statutoryinterpretation.pdf [http://perma.cc/2QTK-8Y2X] ("Courts generally assume that the words of a statute mean what an 'ordinary' or 'reasonable' person would understand them to mean.").

92. William N. Eskridge & Philip P. Frickey, *Foreword: Law as Equilibrium*, 108 HARV. L. REV. 26 app. (1994), *as reprinted in The Rehnquist Court's Canons of Statutory Construction*, NAT'L CONFERENCE OF STATE LEGISLATORS, http://www.ncsl.org/documents/lsss/2013PDS/Rehnquist_Court_Canons_citations.pdf [http://perma.cc/2ZKG-6SSW] ("Expressio unius: expression of one thing suggests the exclusion of others.").

In analyzing the statute's construction, the substantive theory[93] of statutory interpretation would likely yield the same result. The legislative intent of the MTPA is outlined in §403.9323 of the statute:

> It is the intent of the Legislature to protect and preserve mangrove resources valuable to our environment and economy from unregulated removal, defoliation, and destruction . . . . [T]o provide waterfront property owners their riparian right of view, and other rights of riparian property ownership . . . . [T]o encourage waterfront property owners to voluntarily maintain mangroves, encourage mangrove growth, and plant mangroves along their shorelines.[94]

From this excerpt, it is evident that the legislative intent of the MTPA is to protect and preserve mangroves and riparian rights by providing succinct and balanced guidelines to trimming and management.[95] That is to say, protection of invasive mangrove species would be contrary to the statutory intent and the substantive purpose of the Act. However, within the context of invasive species control and eradication, the MTPA only implies that the invasive mangroves are not protected. It in no way mandates or requires their removal through explicit language.

B. Existing Administrative Infrastructure

There are several players in the invasive plant management game in Florida, but the Florida Department of Agriculture and Consumer Services (DACS) has been delegated the authority by the Legislature to implement and oversee the state's noxious weed and prohibited aquatic plant laws.[96] The Florida Department of

93. LARRY M. EIG, CONG. RESEARCH SERV., STATUTORY INTERPRETATION: GENERAL PRINCIPLES AND RECENT TRENDS (2011), https://www.fas.org/sgp/crs/misc/97-589.pdf [http://perma.cc/V4YJ-YMKC] (stating that substantive theory of statutory interpretation instructs courts to favor public policy).

94. FLA. STAT. § 403.9323.

95. Kimbel, *supra* note 14, at 41-42. It is important to note that the legislative intent of this act has two primary components: protecting mangroves and protecting riparian owners' rights. *Id.* These divergent goals are inherently at odds with one another, and the lack of clarity in the legislative intent informs, or perhaps fails to inform, agency-level decision-making and enforcement. *Id.*

96. James S. Neal McCubbins et. al., *Frayed Seams in the "Patchwork Quilt" of American Federalism: An Empirical Analysis of Invasive Plant Species*

Environmental Protection (FDEP) and the Florida Fish and Wildlife Commission (FWC) are required to adopt the rules created by DACS.[97] These agencies work collectively to address the problem of invasive terrestrial and aquatic plants in the state of Florida.

A great example of this delegated authority in action can be seen through the FWC's Invasive Plant Management Section. The Section was established in the late 1800s in response to the spread of non-native aquatic plant species impeding travel and commerce by boat.[98] In 1997, the Invasive Plant Management Section incorporated an Uplands Program to address the increasing threat of exotic terrestrial plant species to native Florida species.[99] This Uplands Program utilizes eleven regional working groups to identify and fund invasive plant species eradication projects on public conservation lands.[100] The Aquatic Plant Management Program, pursuant to the Florida Aquatic Weed Control Act, also allows FWC to "direct the control, eradication, and regulation of

Regulation, 43 ENVTL. L. 35, 66 n.227 (2013) ("Florida began implementing noxious weeds regulation as part of its seed laws during the late 1930s. As part of the state Seed Law, the state Plant Board was created and the Commissioner was granted authority to list other species as needed. In 1945, the laws outlawing noxious weeds were reworked, creating primary and secondary noxious weeds. The transition for Florida, moving the noxious weed regulation to an administrative agency, occurred during the early 1960s. The statutes only left a broad definition to guide the Florida State Department of Agriculture and Consumer Services, removing any named species that had appeared in the statutes. Although Florida has a history of concern with weed control, it was not until 1993 that they actually began to take noxious weeds seriously. During their first specific regulation of noxious weeds, Florida banned or restricted more than 50 different species of weeds. The law enabling the weed list prohibited all introduction or release of plant pests and noxious weeds that may affect the plant life of Florida.") (citations omitted). *See generally* FLA. STAT. ANN. §§ 369.20, 369.25, 581.083 (2016); FLA. ADMIN. CODE ANN. r. 5B-57.006, -64.011 (2016).

97. *See* FLA STAT. ANN. §§ 369.20, 369.25 (West 2016).

98. *Invasive Plant Management*, FLA. FISH & WILDLIFE CONSERVATION COMM'N, http://myfwc.com/wildlifehabitats/invasive-plants/#program [http://perma.cc/C2CE-7Y4F].

99. *Florida Fish and Wildlife Conservation Commission – Invasive Plant Management Section: Annual Reports*¸ FLA. INVASIVE SPECIES P'SHIP¸ http://www.floridainvasives.org/success.cfm [http://perma.cc/9VVB-W9G6].

100. *Upland Plant Management*, FLA. FISH & WILDLIFE CONSERVATION COMM'N, http://www.myfwc.com/uplandplantmanagement [https://perma.cc/YNG6-MRZF]. *See* FLA. STAT. § 369.252 (2016) (providing statutory authority for Upland Program).

noxious aquatic weeds."[101] As one of the lead agencies in the state charged with management, control, and eradication of invasive plant species, FWC heralds itself as the "largest invasive plant management program of its kind in the United States."[102] While this existing agency infrastructure is impressive, it certainly mirrors the vast impacts of invasive plants in Florida.

The Florida Department of Agriculture and Consumer Services administers the Florida Noxious Weed List.[103] This list "prohibits listed plants from cultivation, introduction, collection, and transport without a permit" and contains many species that are listed on the federal noxious weed list.[104] The Noxious Weed and Invasive Plant List Review Committee, a DACS-appointed committee, makes listing recommendations based on a plant species' "invasiveness."[105] Private individuals are also permitted to petition DACS for listing or removal of a species pursuant to certain requirements.[106]

The most recent update to the Noxious Weed List was in December 2016 and at that time included over 80 parasitic and terrestrial weeds.[107] Among these noxious weeds are common plant invaders such as Brazilian pepper (*Schinus terebinthifolius*), melaleuca (*Melaleuca quinquenervia*), and Australian pine (*Casuarina equisetifolia*).[108] The inclusion of these species, all of which are known coastal or wetland invasive plants that are

101. *Scope of Aquatic Plant Management in Florida Waters*, UNIV. OF FLA. INST. OF FOOD & AGRIC. SCIS., http://plants.ifas.ufl.edu/manage/developing-management-plans/scope-of-aquatic-plant-management-in-florida-waters/ [http://perma.cc/L47G-JTDZ].

102. *Invasive Plant Management, supra* note 98.

103. *See Introduced, Invasive, and Noxious Plants*, U.S. DEP'T OF AGRIC., https://plants.usda.gov/java/noxiousDriver [http://perma.cc/VNL3-UCBN] (listing federal and state noxious weeds).

104. *Invasive Non-Native Plant Laws,* FLA. DEP'T OF AGRIC. & CONSUMER SERVS., http://www.freshfromflorida.com/Divisions-Offices/Florida-ForestService/Our-Forests/Forest-Health/Invasive-Non-Native-Plants/Invasive-Non-native-Plant-Laws [http://perma.cc/Z95P-SPNR]. *See generally* FLA. STAT. § 581.083 (providing statutory authority to DACS to enforce permitting system).

105. McCubbins et al., *supra* note 96, at 66.

106. FLA. ADMIN. CODE ANN. r. 5B-57.010(1) (2016).

107. FLA. ADMIN. CODE ANN. r. 5B-57.007; *see* McCubbins et al., *supra* note 96 (highlighting that Florida has been widely regarded as under-regulated with respect to invasive plant species, relying on private citizens and organizations to petition for listing on the state Noxious Weed List).

108. FLA. ADMIN. CODE ANN. r. 5B-57.007.

regularly found imposing upon mangrove ecosystems, suggests that it would be appropriate for *B. gymnorrhiza* and *L. racemosa* to also be included on this list. Listing would make illegal the sale, cultivation, introduction, collection, and/or transportation of the invasive mangrove species without a permit,[109] which would surely aid in preventing further intentional distribution.

However, obtaining a noxious weed listing is more difficult than it may appear at first glance. This is because Florida boasts a very strong, and notorious, aquarium trade.[110] Mangroves are regularly utilized in aquariums as semiaquatic plants to provide habitat for other species.[111] In fact, *B. gymnorrhiza* is touted as an easy aquarium plant to establish – making it very desirable for aquarists.[112] Commercial promotion of exotic mangrove species for aquariums would make it exceedingly difficult to have these species listed on the Florida Noxious Weed List.[113] Apart from these difficulties, listing the invasive mangrove species on the Noxious Weed List is the necessary first step to curbing their spread and ensuring ultimate eradication.

C. Agency Rulemaking: FDEP & the MTPA

Pursuant to the Florida Administrative Procedure Act, the Florida Department of Environmental Protection, as a state agency, has the authority to adopt rules "that implement[] or interpret[] the specific powers and duties conferred by the enabling statute."[114] The MTPA grants FDEP regulating authority to oversee management of mangroves in the state of Florida.[115] Under this authority, FDEP has the power to adopt rules to "implement or interpret" its powers and duties, including its

109. *Invasive Non-Native Plant Laws*, *supra* note 104.

110. *See, e.g., The Lionfish Invasion!: Is the Aquarium Trade to Blame?*, NAT'L OCEANIC ATMOSPHERIC ADMIN. OCEAN SERV. EDUC., http://oceanservice.noaa.gov/education/stories/lionfish/lion03_blame.html [https://perma.cc/Y9YG-GP9D] (noting that Florida aquarium trade has been identified as cause of devastating lionfish invasion in South Florida and beyond).

111. Staletovich, *supra* note 55.

112. *Id.*

113. *Id.*

114. FLA. STAT. § 120.52(8) (2016). *See also* Donna E. Blanton, *State Agency Rulemaking Procedures and Rule Challenges*, 75 FLA. B. J. 1, 34 (2001).

115. FLA. STAT. § 403.9324.

regulatory powers to manage mangrove habitats.[116] As such, FDEP may choose to address invasive mangroves through the exercise of its rulemaking power. While FDEP is not permitted to adopt retroactive rules intended to clarify existing law, FDEP may enact a prospective rule to address invasive species in wetland or coastal ecosystems.[117] Additionally, the rulemaking process is inclusive in that stakeholders are encouraged to provide public comments on the proposed rule itself.[118] Such a rule would provide an avenue through which FDEP could outline specific objectives and methods for removing invasive mangrove species while protecting the native mangroves and safeguarding riparian owners' rights, all while remaining within the bounds of the MTPA. This alternative provides a way for the mangrove invasion to be controlled, even without listing on the state or federal noxious weed lists.

D. Local Ordinances

Florida counties, municipalities, and water management districts also have regulatory authority to oversee invasive plant eradication, management, and control. For example, Miami-Dade County provides for "the reasonable and effective control and regulation" of plant species by the County government.[119] This authority allows the County to issue a Prohibited Plant Species list and a Controlled Species list.[120] Similarly, the South Florida Water Management District (SFWMD) has authority to manage invasive plants within their 16-county jurisdictional area.[121] Even local municipalities, such as the City of Miami, have the ability to make considerations in their ordinances for exotic plant species.[122] Perhaps a more direct way to initiate action in the fight against South Florida's exotic mangrove populations would be to petition the County to amend its Prohibited Plant Species and Controlled

116. FLA. STAT. § 120.52(8).

117. FLA. STAT. § 120.54(1)(f).

118. FLA. STAT. § 120.54(7).

119. *See* MIAMI-DADE COUNTY, FLA., CODE § 19-2 (2011).

120. MIAMI-DADE COUNTY, FLA., CODE §24-49.9; *Prohibited Plants,* MIAMI-DADE CTY. REGULATORY & ECON. RES., http://www.miamidade.gov/environment/prohibited-plants.asp [https://perma.cc/T3FY-DLTA].

121. *Vegetation and Exotic Control*, *supra* note 72.

122. *See generally* MIAMI, FLA., CODE § 17 (2010).

Species lists to include the listing of both *B. gymnorrhiza* and *L. racemosa*.

While local governments and municipalities have a greater capacity to face the invasive species issue head-on, there are some limits. Namely, these governments are constrained by their geo-political boundaries which are "artificial limits not respected by invasive plant movements."[123] Local governments may also lack the resources, both economic and scientific, to address these types of invasions. As such, state intervention seems to be the most effective course for regulating and managing the invasive plant problem in Florida.

E. Non-Governmental Organizations

Florida's NGO community is much more vigilant than its governmental counterpart in addressing the invasive plant issue throughout the state. Namely, the Florida Exotic Pest Plant Council (FLEPPC) is an organization that administers a state-wide comprehensive invasive plant species list every two years.[124] While this is a non-regulatory and non-binding list, many agencies, counties, and other entities rely on this list for invasive plant management guidance. Notably, *B. gymnorrhiza* and *L. racemosa* are already listed with FLEPPC.[125] The University of Florida's Institute of Food and Agricultural Sciences (UF IFAS) and its Center for Aquatic and Invasive Plants work closely with FLEPPC and other organizations to ensure that the best science provides

123. McCubbins et al., *supra* note 96, at 72.

124. *See Florida Exotic Pest Plant Council Invasive Plant Lists*, FLA. EXOTIC PEST PLANT COUNCIL, http://www.fleppc.org/list/list.htm [https://perma.cc/R45L-7EQA].

125. *B. gymnorrhiza* is listed as a Category II species and *L. racemosa* is a Category I species. Category I species are those invasive exotics that are altering native plant communities by displacing native species, changing community structures or ecological functions, or hybridizing with natives. Category II species are those invasive exotics that have increased in abundance or frequency, but that have not yet altered Florida plant communities to the extent shown by Category I species. Importantly, these definitions do not rely on the economic severity or geographic range of the problem, but rather on the documented ecological damage caused. E-mail from Karen Brown, Treasurer, Fla. Exotic Pest Plant Council, to author (Jan. 4, 2017, 03:10 EST) (on file with author).

the best guidance for species listing and management techniques.[126]

Other organizations, such as the Florida Invasive Plant Species Partnership – a collaborative effort between governmental and non-governmental organizations to combat non-native species – are also working on these issues.[127] This partnership contains a Southeast Invasive Upland Plant Working Group, which works to address the spread of these invasive plants in South Florida,[128] but could focus their efforts more narrowly on the growing invasive mangrove issue.

These non-governmental organizations can provide a platform wherein the County, the water management districts, state agencies, scientific researchers, non-governmental organizations and other entities could adopt an integrated management framework whereby all entities work collaboratively to implement eradication strategies for the invasive mangrove species in South Florida.

F. Models for Management

The discovery of exotic mangroves in Florida is not the first instance of a mangrove invasion in the United States. In fact, Hawaii has been dealing with a mangrove invader of its own for some time now: *Rhizophora mangle* – Florida's own native and beloved red mangrove. Prior to 1900, the Hawaiian archipelago had no mangroves.[129] In 1902, American Sugar Company introduced red mangroves in an attempt to curtail soil erosion in the fields and to stabilize coastal mud flats on the island of Molokai.[130] The red mangroves were so effective that 20 years later, 14,000 more red mangroves were imported from the Philippines.[131] Today, the red mangrove in Hawaii is well-

126. Telephone interview with Karen Brown, Educational Coordinator, UF IFAS (Jan. 4, 2017).

127. *See* FLA. INVASIVE SPECIES P'SHIP, https://www.floridainvasives.org/ [https://perma.cc/7WJW-UHE6].

128. *See Southeast Invasive Upland Plant Working Group*, FLA. INVASIVE PLANT SPECIES P'SHIP, https://www.floridainvasives.org/workinggroups/southeast.html [https://perma.cc/98WM-YDNR].

129. Staletovich, *supra* note 55.

130. *Id.*

131. *Id.*

established, found on nearly all of the major islands, and wreaking havoc on the native ecosystems.[132] In particular, the red mangrove contributes to decreased water quality, nutrient loading and anoxia, sedimentation, and hypersalinization.[133] These conditions favor other exotic species, including fish and birds, while excluding native organisms such as corals.[134] Mangroves have also had documented adverse impacts on archaeological resources and their destruction of habitat has imperiled endangered waterbirds.[135]

Needless to say, Hawaii's concerns with the eradication of the red mangrove are well-founded. As one can imagine, the red mangrove is not the only invasive species of concern for the archipelago. In fact, *B. gymnorrhiza* and the mangrove associate *Conocarpus erectus* have both established self-maintaining populations in Hawaii.[136] Apart from mangroves, Hawaii has a problem with invasive species in general. As such, the Hawaii Invasive Species Council (HISC) was established in 2003 by the state legislature in order to provide cabinet level guidance, coordination, and planning for the eradication and control of invasive species.[137] The Council is in the process of creating an official state "invasive" designation in order to formally define and identify invasive species in Hawaii.[138]

Hawaii has numerous statutes and administrative rules governing the control and eradication of invasive species.[139] However, the HISC places Hawaii apart from Florida, which has no government agency or organization devoted specifically and solely to addressing the threats that invasive species pose. While the HISC is still developing regulations to create binding "invasive" designations, at least that work is in progress. In contrast, Florida's Noxious Weed List fails to list many invasive

132. *Mangrove: The Invasive Marine Weed Tree*, MALAMA O PUNA, http://www.malamaopuna.org/waiopae.php [https://perma.cc/FGF7-X8JB].

133. *See* James A. Allen, *Mangroves as Alien Species: The Case of Hawaii*, 7 GLOBAL ECOLOGY & BIOGEOGRAPHY LETTERS 61 (1998).

134. *Id.*

135. *Id.* at 67.

136. *Id.* at 61.

137. *About*, HAW. INVASIVE SPECIES COUNCIL, http://dlnr.hawaii.gov/hisc/about/ [https://perma.cc/WCF9-7TH4].

138. *Hawaii's Invasive Species Agencies and Policies*, HAW. INVASIVE SPECIES COUNCIL, http://dlnr.hawaii.gov/hisc/info/policy/ [https://perma.cc/EH2A-77B6].

139. *Id.*

plant species including the invasive mangroves, which have been known about since 2008. This nonchalant approach to addressing invasive mangrove species in Florida is hardly precautionary. Florida should look to Hawaii and other states[140] with successful invasive species management regimes as models for control and eradication of the invasive mangroves.

V. WHERE WE "STAND": FUTURE RECOMMENDATIONS FOR INVASIVE MANGROVES IN SOUTH FLORIDA

Ignorance may be bliss when it comes to invasive mangroves, although it does seem that the current status of invasive mangrove species in South Florida is not too grim. The Matheson Hammock invasion is seemingly under control and the Kampong invasion has not caused any other known outbreaks. However, there are some looming uncertainties to be considered. First, we are unsure if there are any other invasions of *B. gymnorrhiza* in South Florida. Scientists believe that the likelihood of other invasions from the Kampong are extremely high – they just have not found them yet. Second, while the Matheson Hammock invasion is relatively under control right now, one small tropical storm – an all too frequent occurrence in South Florida – would take *L. racemosa* seeds wherever the wind blows. Third, the impacts on native mangrove ecosystems are simply unstudied and unknown. Even the smallest exotic mangrove invasion could potentially compromise our valuable mangrove ecosystems by impacting nutrient cycling, food web interactions, and shoreline protection due to impacts on forest structure. Finally, the impacts associated with climate change on

140. *See, e.g.,* Cecilia Weibert, Aquatic Invasive Plant Species: Risk Assessments in the State of Michigan 10-12 (Dec. 2015) (unpublished M.P.S. Internship Report, University of Miami) (on file with author) (The state of Michigan may be referred to as a model for invasive species management. In particular, Michigan has had success in management of aquatic invasive species through implementation of its Aquatic Invasive Species Council. Further, Michigan's adoption of the USDA Animal and Plant Health Inspection Service Plant Protection and Quarantine weed risk assessment protocols have provided the state with a means of categorizing risk in order to better identify and catalog invasive species on Michigan's prohibited and restricted species list. This model could be adopted in Florida in order to better categorize risk presented by invasive species and prioritize their removal.). *See* McCubbins et al., *supra* note 96, at 73-81.

native and non-native mangrove species are certainly up for contemplation. Will ranges expand? Will these introduced species dominate in a warming climate? How will the species interact with increased climatic disturbance? Will native species be able to recover? Such a myriad of unknown factors, more than anything, warrants a precautionary approach to management of invasive mangrove species.

An essential part of an effective precautionary approach to management of invasive mangrove species requires integration into the legal framework. As such, *L. racemosa* and *B. gymnorrhiza* should, at the very least, be listed on the Florida Noxious Weed List. The Mangrove Trimming and Preservation Act should be referenced as the authority by which state and local agencies can engage in eradication and management strategies for these species. Alternatively, state agencies should consider exercising their rulemaking authority to enact a rule under which these invasive species can be more aptly controlled. Additionally, a Florida Invasive Species Council should be established in order to promote horizontal and vertical integration between different levels and areas of government. This council should facilitate invasive species policy in the state by commissioning scientific studies, adopting risk assessment techniques to prioritize eradication, overseeing thoughtful and impactful use of funding, and assisting with planning strategies and management techniques. Finally, localized nuisance abatement control statutes are imperative to effectively respond to this invasion, and the many others that plague South Florida.[141]

Florida's mangroves are valued by many for the ecosystem services they provide – both environmentally and economically. However, it is possible that *B. gymnorrhiza* and *L. racemosa* are threatening the future of the native mangrove species. In the almost ten years since the discovery of the mangrove invasion in Florida, very little has been done to address and curtail the spread of these species. With the immediate and future threats that climate change poses to our South Florida ecosystems, it is more important than ever to refine our state framework for invasive

141. *See generally* Bill D. Nelson, *Controlling Harmful Non-Native Plants at Local Levels: Private Rights and the Public Good*, 4 HASTINGS W.-N.W. J. ENVTL. L. & POL'Y 75 (1997) (analyzing application of state and local tools to control of non-native plant species).

species control and management. The state government, local governments, coastal planners, riparian owners, and non-governmental organizations must all have a hand in collaborating and addressing the abatement of the spread of invasive mangroves throughout South Florida.