Florida on the Coast of Climate Change: Responding to Rising Seas

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INTRODUCTION

According to a report released by the Intergovernmental Panel on Climate Change ("IPCC"), "[w]arming of the climate system is unequivocal,"[1] and is very likely[2] attributable to anthropogenic influences, namely, the release of greenhouse gases ("GHGs") into the atmosphere.[3] Global atmospheric concentrations of GHGs, including carbon dioxide,[4] methane,[5] and nitrous oxide, have increased markedly as a result of human activities since 1750.[6] These gases trap solar heat in the atmosphere that would otherwise radiate away;[7] consequently, the global average surface temperature has risen 0.76 degrees Celsius since the beginning of the Industrial Revolution.[8]

The IPCC further reported that global warming from increased GHG concentrations has directly contributed to a rise in sea level.[9] Over the last

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[1] WORKING GROUP I, FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS, SUMMARY FOR POLICY MAKERS 5 (2007), *available at* http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf [hereinafter IPCC FAR WGI]. Although some climate variability is natural, natural forces alone cannot explain the global warming experienced in the second half of the 20th century. *Id.* at 10.

[2] Working Group I of the IPCC uses the following terms to indicate the likelihood of a particular outcome or result: virtually certain > 99% probability of occurrence, very likely > 90%, likely > 66%, more likely than not > 50%, unlikely < 33%, very unlikely <10%, extremely unlikely <5%. *Id.* at 3 n.6.

[3] *Id.* at 5 ("The observed widespread warming of the atmosphere and ocean, together with ice mass loss, support the conclusion that it is *extremely unlikely* that global climate change of the past fifty years can be explained without external forcing, and *very likely* that it is not due to known natural causes alone.").

[4] Carbon dioxide is the main byproduct of fossil fuel combustion, and results from any energy production that uses oil, coal, natural gas, or other solid waste fuels. Major sources of carbon dioxide emissions include industry, buildings, appliances, cement kilns, agriculture industry and processes, transportation, and energy supply and conversion. ALEXANDER GILLESPIE, CLIMATE CHANGE, OZONE DEPLETION, AND AIR POLLUTION: LEGAL COMMENTARIES WITH POLICY AND SCIENCE CONSIDERATIONS 42 (Brill Academic 2005).

[5] Methane is released from landfills and natural gas and oil systems, and during coal mining and livestock manure management. DAVID WOOLEY & ELIZABETH MORSS, CLEAN AIR ACT HANDBOOK § 6:29 (2006).

[6] IPCC FAR WGI, *supra* note 1, at 2. Between 1970 and 2004 alone, emissions of carbon dioxide increased 80%. WORKING GROUP III, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE FOURTH ASSESSMENT REPORT, CLIMATE CHANGE 2007: MITIGATION OF CLIMATE CHANGE, SUMMARY FOR POLICY MAKERS 3 (2007), *available at* http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-spm.pdf [hereinafter IPCC FAR WGIII].

[7] *See* Massachusetts v. EPA, 127 S. Ct. 1438, 1446 (2007) ("[W]hen carbon dioxide is released into the atmosphere, it acts like the ceiling of a greenhouse, trapping solar energy and retarding the escape of the reflected heat.").

[8] IPCC FAR WGI, *supra* note 1, at 5. Notably, the U.S. Environmental Protection Agency "does not dispute the existence of a causal connection between man-made greenhouse gas emissions and global warming." *Massachusetts v. EPA*, 127 S. Ct. at 1457.

[9] IPCC FAR WGI, *supra* note 1, at 7, 17.

century, global average sea level rose a total of 6.69 inches,[10] and is currently rising at "an alarming rate"[11] of an eighth of an inch per year.[12] The rise in sea level results from a combination of thermal expansion of warmer water and the widespread melting of glaciers and ice caps.[13] Although an increase of a fraction of an inch per year hardly seems significant, the last time that the polar regions were significantly warmer than their current temperature for an extended period, which occurred about 125,000 years ago, melting of polar ice led to thirteen to twenty feet of sea level rise.[14] An increase of this size would completely submerge one-third of Florida's landmass.[15]

Moreover, the IPCC predicts that sea level will continue to rise regardless of any future attempts to decrease GHG emissions.[16] In fact, the IPCC projects that "[b]oth past and future anthropogenic carbon dioxide emissions will continue to contribute to warming and sea level rise for more than a millennium," even if GHG emissions levels were *immediately* stabilized.[17] Thermal expansion alone will continue for many centuries and could result in a two-and-a-half-foot increase in sea level by 2300.[18] In addition, "[w]arming tends to reduce land and ocean uptake of atmospheric carbon dioxide, increasing the fraction of anthropogenic emissions that remains in the atmosphere."[19] As a result, the IPCC predicts that changes in the global climate system during the 21st century will very likely be larger than those observed during the 20th century.[20] Therefore, the warming trend, and concomitant sea level rise, is likely to increase exponentially, rather than linearly, even if GHG emissions are reduced significantly and without delay. The fact that carbon dioxide remains in the atmosphere for decades[21] and oceans may store heat for centuries[22] ensures that

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[10] *Id.*

[11] Rebecca Elizabeth Jacobs, Comment, *Treading Deep Waters: Substantive Law Issues in Tuvalu's Threat to Sue the United States in the International Court of Justice*, 14 PAC. RIM L. & POL'Y J. 103, 106 (2005).

[12] IPCC FAR WGI, *supra* note 1, at 5. Global average sea level increased about 1.8 millimeters per year from 1961 to 2003; however, between 1993 and 2003, this rate almost doubled to 3.1 millimeters per year. *Id.*

[13] *See* Table SPM.1, *id.* at 7.

[14] *Id.* at 9.

[15] *Nations issue road map to deal with warming: Emissions curbs won't cripple economies, report states, though U.S. wary*, MSNBC, May 4, 2007, http://www.msnbc.msn.com/id/18466213/.

[16] IPCC FAR WGI, *supra* note 1, at 16.

[17] *Id.* at 17.

[18] *Id.*

[19] *Id.* at 13.

[20] *Id.*

[21] Carbon dioxide, once in the atmosphere, remains there for more than 100 years. Steven Ferrey, *Why Electricity Matters, Developing Nations Matter, and Asia Matters Most of All*, 15 N.Y.U. ENVTL. L.J. 113, 119 (2007).

[22] Karen N. Scott, *The Day After Tomorrow: Ocean CO_2 Sequestration and the Future of Climate Change*, 18 GEO. INT'L ENVTL. L. REV. 57, 59 (2005). The rise in sea level is extremely

previous emissions will keep warming the planet for decades after GHG concentrations stabilize. Thus, no matter how much future emissions are abated, sea levels will continue to rise.[23] In fact, global average sea level could rise an additional four to thirty-five inches this century.[24]

In light of these projections, the state of Florida occupies a uniquely unfavorable position as the "canary in the mine shaft of sea level rise."[25] Boasting over 8,000 miles of coastline and 11,000 miles of rivers, streams, and waterways, the state is surrounded by water on three sides.[26] No part of the state is more than sixty miles from the ocean, and because the coasts have low slopes and the state is relatively flat, a small rise in sea level produces a large inland shift of coastline.[27] At the mean projected rate, Florida will lose almost fifty percent of its critical salt marsh and eighty-four percent of tidal flats, as well as fourteen percent of its dry land and thirty percent of its beaches by 2100.[28]

Climate change in general, and sea level rise in particular, stands to devastate Florida's economy. The state's economy relies heavily on agriculture, tourism, and recreational fishing opportunities, all of which are likely to be severely threatened by rising seas, especially when considered in addition to the existing stresses caused by other influences such as population growth, land-use changes, and pollution.[29] The coastal zone, in addition to being the "economic engine"[30] of Florida, is also important ecologically.[31] With over eighty-seven different ecosystem types, forty-one aquatic preserves, and one of the world's largest

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slow because of the high heat capacity of the ocean; the ocean has been absorbing 80% of the heat added to the global climate system, considerably delaying the full effects of the increased temperature. IPCC FAR WGI, *supra* note 1, at 5; Denis Culley, Comment, *Global Warming, Sea Level Rise and Tort*, 8 OCEAN & COASTAL L.J. 91, 99 (2002).

[23] IPCC FAR WGI, *supra* note 1, at 16; *see also* Samuel Pyeatt Menefee, *"Half Seas Over": The Impact of Sea Level Rise on International Law and Policy*, 9 UCLA J. ENVTL. L. & POL'Y 175, 180 (1991) (noting that "there is a lag between an increase in temperature and a rise in ocean level, such that any diminution or reversal of the greenhouse effect will not prevent a certain amount of sea level rise.").

[24] JULIE HAUSERMAN, FLORIDA'S COASTAL AND OCEAN FUTURE: A BLUEPRINT FOR ECONOMIC AND ENVIRONMENTAL LEADERSHIP 21 (2007), *available at* http://www.nrdc.org/water/oceans/florida/flfuture.pdf.

[25] BARRY G. RABE, STATEHOUSE TO GREENHOUSE 48 (Brookings Institution Press 2004).

[26] *See* HAUSERMAN, *supra* note 24, at 2.

[27] Dominick J. Graziano, *Global Warming: An Introduction to the State of the Science and a Survey of Some Legal Responses*, 79 FLA. BAR J. 1, 2 (2005) (reporting that a half-meter increase in sea level rise could inundate 4,000 square kilometers of Florida); HAUSERMAN, *supra* note 24, at 2.

[28] HAUSERMAN, *supra* note 24, at 22.

[29] U.S. ENVIRONMENTAL PROTECTION AGENCY, OFFICE OF POLICY, PLANNING AND EVALUATION, CLIMATE CHANGE AND FLORIDA, EPA 230-F-97-008i, at 2 (2007), *available at* http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/SHSU5BUKSV/$File/fl_impct.pdf [hereinafter CLIMATE CHANGE AND FLORIDA]; Graziano, *supra* note 27, at 2.

[30] HAUSERMAN, *supra* note 24, at vi.

[31] *See* Robert J. Nicholls & Jason A. Lowe, *Benefits of mitigation of climate change for coastal areas*, 14 GLOBAL ENVTL. CHANGE 229 (2004).

underwater refuges, Florida is a "biodiversity hot spot."[32] Salt-water intrusion and storm damage expected to result from sea level rise threaten the survival of these resources and ecosystems.[33]

The U.S. Supreme Court recently acknowledged that "[t]he harms associated with climate change are serious and well recognized."[34] Sea level rise from climate change poses "the most direct risk to human settlement . . . adversely affecting virtually all aspects of social and economic life, threatening agriculture and water supply, and displacing millions of people living in low lying areas."[35] These effects, detailed in Part I of this Article, will force human society to adapt and evolve. The only question is whether the necessary changes will happen in advance through prior planning or through a chaotic reaction to circumstance. The law can provide a solution that respects inevitable changes while maintaining order and traditional values.

In order to avoid the potentially devastating environmental and economic impacts of sea level rise, Florida needs to take action to prevent further sea level rise, mitigate the unavoidable effects, and adapt to rising seas.[36] Choices made now are essential to controlling and curbing future sea level rise from reaching the worst-case scenario.[37] Part II describes methods of reducing GHG emissions through the creation of a carbon tax, the development and use of alternative technology, and improving energy efficiency. In addition, the possibility of decreasing atmospheric concentrations of GHGs through carbon sequestration techniques is discussed in this section.

To the extent that some rise in sea level is inevitable, action must be taken to mitigate the damages of the probable effects of sea level rise and adapt to rising seas. Part III discusses ways to minimize the damages caused by sea level rise. Advanced planning, holding back the sea, and promoting wetland development will all decrease the economic and social cost of sea level rise. Part IV outlines methods for adapting to the altered coastlines through land management

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[32] HAUSERMAN, *supra* note 24, at 8. Florida is also home to three of the nation's National Estuarine Research Reserves, and the most extensive living coral reef system in North America. *Id.* Fish diversity is essential to both economic value and recreation in Florida. *Id.* at 15. Florida is one of the nation's premiere destinations for recreational fishing, drawing $8.3 billion each year. *Id.* at 16.

[33] *See infra* part I.C.

[34] Massachusetts v. EPA, 127 S. Ct. 1438, 1455 (2007).

[35] Ferrey, *supra* note 21, at 120. *See also* CLIMATE CHANGE AND FLORIDA, *supra* note 29, at 3.

[36] In fact, Florida Governor Charlie Crist has committed the state to face the "monumental challenge" of sea level rise head-on through development of policy and technology and moral leadership. Charlie Crist, Governor of Florida, State of the State Address (Mar. 6, 2007), *available at* http://www.flgov.com/pdfs/2007sos.pdf. Moreover, he recognizes that by doing so, the state can address three important goals: "addressing climate change, promoting Florida agriculture, and weaning our country from reliance on foreign oil." *Id.*

[37] *See* IPCC FAR WGIII, *supra* note 6, at 22 ("Mitigation efforts over the next two to three decades will have a large impact on opportunities to achieve lower stabilization levels.").

practices and, sometimes, complete abandonment of high-risk property.

Florida is extremely vulnerable to the expected effects of sea level rise; the state is in position to lose significant land mass, coastal infrastructure, ecosystems, and natural defense mechanisms, and billions of dollars in the agricultural and tourist industries. Therefore, a combination of the methods discussed in this Article — prevention, mitigation, and adaptation — is necessary to adequately address the problem of sea level rise in Florida both effectively and efficiently.[38]

I. EFFECTS OF SEA LEVEL RISE

Sea level is already rising seven to nine inches per century along much of Florida's coast — about three inches more than the global average.[39] By 2100, this is likely to increase to eighteen to twenty inches per century.[40] This increase is likely to inundate wetlands and lowlands along both the Gulf and Atlantic coasts.[41] In addition, Floridians can expect to experience losses of land and structures, accelerated coastal erosion, exacerbated flooding and increased vulnerability to storm damage, and decreased supply of freshwater as a result of salt-water intrusion.[42]

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[38] *See, e.g.*, Michael Meacher, *Political Will is Needed to Deliver Kyoto's Goal*, FIN. TIMES, Oct. 18, 2004, at 13, *available at* 2004 WLNR 9806078 ("No one policy is sufficient to confront climate change. It requires a combination of contraction and convergence to force down the use of fossil fuels; a global switch, led by fiscal incentives, into renewable sources of energy; and a huge campaign to maximize conservation and relentlessly squeeze the prodigious waste of energy.").

[39] CLIMATE CHANGE AND FLORIDA, *supra* note 29, at 3; GLOBAL CLIMATE CHANGE: WHAT DOES IT MEAN FOR SOUTH FLORIDA AND THE FLORIDA KEYS? 11 (1999) [hereinafter SOUTH FLORIDA], *available at* http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/SHSU5BUKPX/$File/florida.pdf

[40] CLIMATE CHANGE AND FLORIDA, *supra* note 29, at 3.

[41] *See id.*

[42] *See id.* The international community faces even greater challenges as sea levels continue to rise. Although beyond the scope of this article, these include boundary disputes and navigational issues where sea level rise changes surface shapes and creates new waterways. Menefee, *supra* note 23, at 178. Moreover, some whole countries may disappear altogether, creating a new phenomenon of "environmental refugees." *Id.* ("1 billion people, nearly a fifth of the world's population, could become greenhouse refugees in the 21st century."). The small island nation of Tuvalu is expected to be the first populated island to become completely submerged, and the Tuvaluan government is already contemplating relocation of the entire population. Culley, *supra* note 22, at 106; Jacobs, *supra* note 11, at 103-04. Finally, nations can expect security issues to arise as nations compete for fewer resources. *See* Henry W. McGee, Jr., *Litigating Global Warming: Substantive Law in Search of a Forum*, 16 FORDHAM ENVTL. L.J. 371, 385 (2005) ("As productive land and other resources disappear, increasingly dense populations cause[d] by relocation, ethnic differences, as well as other differences, raise the specter or civil and international conflict on an aggravated and widespread scale."); *see also* Sumudu Atapattu, *Sustainable Development and Terrorism: International Linkages and a Case Study of Sri Lanka*, 30 WM. & MARY ENVTL. L. & POL'Y REV. 273, 289-90 (identifying close relationship between environmental degradation and international peace and security).

A. Loss of Land

Higher sea levels will result in loss of both dry land and wetlands. For example, a two-foot rise in sea level would inundate 10,000 square miles of dry land.[43] Although the majority of the dry land within two feet of high tide is undeveloped, coastal areas are growing rapidly[44] and are often home to recreational resorts that are vital to the economies of surrounding communities.[45] In 2005 alone, eighty-six million tourists were drawn to Florida's sunshine and sandy beaches, generating $63 billion in revenue and almost one million jobs.[46]

In addition to the inevitable loss of dry land to flooding, coastal erosion will accelerate. A two-foot rise in sea level will erode beaches by 100 to 200 feet if efforts to nourish beaches are not expanded.[47] Moreover, less sand will be returned to the dry part of the beach when the offshore bottom rises with the sea.[48] In Florida, approximately 328 miles of sandy beaches — comprising forty percent of the state's coastline — are eroding enough to threaten development and recreational areas.[49]

The combination of rapidly encroaching seas and accelerated erosion decreases the resiliency of ecosystems and human settlements by destroying the beaches, dunes, and wetlands that provide natural protection against flooding and wave action. Wetlands in particular provide species habitat, play a key role in nutrient uptake, provide recreational opportunities, and protect local areas from flooding.[50] These systems are particularly vulnerable to sea level rise because they are generally located within a few feet of sea level.[51] Many coastal ecosystems, such as mangroves, reefs, and sea grass beds face extinction, threatening reef fisheries and the livelihood of the individuals who rely on these resources.[52] Florida can expect to experience all of these effects.[53]

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[43] U.S. ENVIRONMENTAL PROTECTION AGENCY, COASTAL ZONES AND SEA LEVEL RISE, CLIMATE CHANGE — HEALTH AND ENVIRONMENTAL EFFECTS, http://epa.gov/climatechange/effects/coastal/index.html (last visited Mar. 10, 2008) [hereinafter HEALTH AND EFFECTS].

[44] *Id.*

[45] *Id.*

[46] NATURAL RESOURCES DEFENSE COUNCIL, OCEAN FACTS: GLOBAL WARMING'S EFFECTS ON FLORIDA'S OCEANS AND COASTS DEMAND IMMEDIATE ACTION (2007).

[47] SOUTH FLORIDA, *supra* note 39, at 8-9.

[48] *Id.* at 8.

[49] MONROE COUNTY GROWTH MANAGEMENT DIVISION, ET AL., SAVING FLORIDA'S VANISHING SHORES 1 (2002), *available at* http://www.epa.gov/climatechange/effects/coastal/saving_FL.pdf [hereinafter VANISHING SHORES].

[50] HEALTH AND EFFECTS, *supra* note 43.

[51] *Id.*

[52] WORKING GROUP II, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE FOURTH ASSESSMENT REPORT, CLIMATE CHANGE 2007: IMPACTS, ADAPTATION, AND VULNERABILITY, SUMMARY FOR POLICY MAKERS 13 (2007), *available* http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-spm.pdf [hereinafter IPCC FAR WGII]; GILLESPIE, *supra* note 4, at 115-16.

Human development in coastal areas prevents regeneration and inland migration of these important ecosystems, exacerbating the effects of sea level rise on wetland ecosystems.[54] For example, as the sea level rises, the outer boundaries of wetlands erode.[55] Normally, new wetlands would form inland as previously dry areas were flooded by higher water levels.[56] However, where the sea rises too rapidly, or where bulkheads and dikes prevent landward migration, the new wetlands, if able to migrate at all, will be much smaller than those lost to sea level rise.[57] A two-foot rise in sea level could eliminate seventeen to forty-three percent of the United States' wetlands, with Florida and Louisiana bearing the majority of the loss.[58] Dunes and beaches migrate similarly, and also threaten to be squeezed out between coastal development and rising seas.[59]

B. Loss of Property

Increased property loss is expected to occur as coastal floods become more severe. Higher sea levels will slow the rate at which low-lying areas can drain.[60] In addition, storm surges will have a higher base to build upon when sea levels rise.[61] In the absence of other measures, a sea level rise of 1.2 feet would increase five-fold the number of people flooded by storm surges.[62] The loss of beaches, dunes, and coastal wetlands increases vulnerability to flood damage, as these features would otherwise protect coastal property from waves and flooding.[63]

In South Florida alone, more than $1.3 trillion worth of real estate is vulnerable to storm damage.[64] Insured losses in Florida from hurricanes Charley, Frances, Ivan, and Jeanne in 2004 totaled more than $20 billion, and some estimates attribute the losses from Hurricane Katrina at more than $100 billion.[65]

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[53] CLIMATE CHANGE AND FLORIDA, *supra* note 29, at 3.

[54] *See* IPCC FAR WGII, *supra* note 52, at 12.

[55] HEALTH AND EFFECTS, *supra* note 43.

[56] *Id.*

[57] *Id.*

[58] *Id.*

[59] For further discussion on wetland protection and curbing coastal development, see discussion *infra* Part IV.C.

[60] Martin M. Randall, *Coastal Development Run Amuck: A Policy of Retreat May Be the Only Hope*, 18 J. ENVTL. L. & LITIG. 145, 180 (2003); *see also* VANISHING SHORES, *supra* note 49, at 2.

[61] Randall, *supra* note 60, at 180; *see also* VANISHING SHORES, *supra* note 49, at 2.

[62] Gordon McGranahan, Deborah Balk, & Bridget Anderson, *The Rising Tide: Assessing the Risk of Climate Change and Human Settlements in Low Elevation Coastal Zones*, 19 ENV'T. & URBANIZATION 17, 20 (2007), *available at* http://eau.sagepub.com/cgi/reprint/19/1/17.

[63] IPCC FAR WGII, *supra* note 52, at 9; *see also* HEALTH AND EFFECTS, *supra* note 43.

[64] SOUTH FLORIDA, *supra* note 39, at 2.

[65] NAT'L WILDLIFE FED'N & FLA. WILDLIFE FED'N, AN UNFAVORABLE TIDE: GLOBAL WARMING, COASTAL HABITATS AND SPORTFISHING IN FLORIDA 44 (2006), *available at*

In addition to private property, transportation infrastructure is likely to be severely disrupted by sea level rise. Most roads are lower than the surrounding lands, allowing the land to drain into the streets.[66] As sea level rises, these drainage systems become less effective.[67] Roads may also be threatened by erosion,[68] many airports are built along tidal waters,[69] and port facilities will be left at a suboptimal elevation as sea level rises.[70] These losses are particularly significant if the roads are part of critical evacuation routes;[71] increased evacuation times either increase risk to life or require evacuation orders be given sooner, often before a threat can properly be assessed.[72]

C. Water Quality

Rising sea levels increase the salinity of both surface and ground water through salt-water intrusion into wetlands, bays, aquifers, and rivers.[73] Fresh water supplies are at risk, especially in South Florida, where the water table is only sixty feet deep.[74] There, the salt-water intrusion from a one-foot rise in sea level would shrink the water table to only twenty feet, significantly decreasing the availability of fresh water.[75]

Rising sea levels threaten to inundate the Florida Everglades with salt water, jeopardizing both the Biscayne Aquifer, and the health of the area's wildlife.[76] The Biscayne Aquifer provides almost all of the fresh water for Miami, the Keys, and southeast Florida, serving more than three million people.[77] A major effort is currently underway to preserve the Everglades;[78] officials hope to

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http://www.targetglobalwarming.org/files/AnUnfavorableTideReport.pdf [hereinafter UNFAVORABLE TIDE].

[66] Jim Titus, *Does Sea Level Rise Matter to Transportation Along the Coast?*, *in* DOT CENTER FOR CLIMATE CHANGE & ENVIRONMENTAL FORECASTING, THE POTENTIAL IMPACTS OF CLIMATE CHANGE ON TRANSPORTATION 139 (2002), *available at* http://climate.dot.gov/publications/workshop1002/titus.pdf [hereinafter Titus, *Transportation*].

[67] *Id.* at 5.

[68] *Id.*

[69] Airports in New York City, Boston, and Washington, D.C. are among the many. *Id.* at 4.

[70] *Id.*

[71] *Id.* at 5.

[72] *Id.*

[73] HEALTH AND EFFECTS, *supra* note 43.

[74] SOUTH FLORIDA, *supra* note 39, at 9.

[75] *Id.*

[76] *See* VANISHING SHORES, *supra* note 49, at 3.

[77] RELATIVE RISK ASSESSMENT OF MANAGEMENT OPTIONS FOR TREATED WASTEWATER IN SOUTH FLORIDA 2-10 (2002), *available at* http://www.epa.gov/region4/water/uic/downloads/ra/02-background.pdf.

[78] James G. Titus, *Does the U.S. Government Realize the Sea is Rising? How to Restructure Federal Programs So That Beaches And Wetlands Survive*, 30 GOLDEN GATE U. L. REV. 717, 770 (2000) [hereinafter Titus, *Restructure*] ("Almost everyone would vote for adaptation "); VANISHING SHORES, *supra* note 49, at 2.

counteract the salt-water intrusion by pumping freshwater into the area to keep the salt water out.[79]

A decline in water quality also influences the agricultural sector. Elevation of the salt-water table and the resulting salt-water intrusion will limit the amount of arable land, resulting in less food production and crop exports.[80] Elsewhere, salt water intrusion has already forced citizens to alter their farming practices. In Tuvalu, an island in the South Pacific, salt water has contaminated the soil and citizens have been forced to grow their crops in tin pots or relocate to less productive soils.[81] In Bangladesh, farmers have transformed their traditional rice cultivating lands into prawn farms to accommodate the saltier water.[82] Farmers on the East Coast of the United States have seen a decrease in arable land in the past ten years as a result of salt-water intrusion.[83] Because agriculture is a multi-billion-dollar business in Florida, the effect of salt-water intrusion on the state's ability to produce citrus fruits, sugarcane, and tomatoes could be devastating.[84]

D. Storm Damage

As discussed above, increased damage to land and personal property is expected to result from floods, erosion, and lost coastal defenses. However, this risk will be exacerbated if, as the IPCC projects, violent storm activity also increases.

Florida is already exposed to significant hurricane activity, but the IPCC predicts that the combination of warmer air and surface water temperatures will result in more frequent violent storm activity.[85] Although scientists cannot say at present whether more or fewer hurricanes will occur in the future with global warming, the hurricanes that do occur are expected to be more intense, with larger peak wind speeds and significantly heavier rainfall than those formed under present day climate conditions.[86]

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[79] Titus, *Restructure*, *supra* note 78, at 770.

[80] James G. Titus, *Rising Seas, Coastal Erosion And The Takings Clause: How To Save Wetlands And Beaches Without Hurting Property Owners*, 57 MD. L. REV. 1279, 1306 (1998) [hereinafter Titus, *Rising Seas*].

[81] Culley, *supra* note 22, at 106. For a discussion of the challenges facing small island nations confronting rising sea levels, see generally Alexander Gillespie, *Small Island States in the Face of Climatic Change: The End of the Line in International Environmental Responsibility*, 22 UCLA J. ENVTL. L. & POL'Y 107 (2003).

[82] Mark Hertsgaard, *On the Front Lines of Climate Change*, TIME, Apr. 9, 2007, at 102.

[83] Titus, *Rising Seas*, supra note 80, at 1306.

[84] FEELING THE HEAT IN FLORIDA: GLOBAL WARMING ON A LOCAL LEVEL 13 (Jeff Fielder et al. eds., 2001), *available at* http://www.nrdc.org/globalwarming/florida/florida.pdf.

[85] IPCC FAR WGI, *supra* note 1, at 15.

[86] *See* National Oceanic and Atmospheric Administration, Geophysical Fluid Dynamics Laboratory, *Global Warming and Hurricanes*, http://www.gfdl.gov/~tk/glob_warm_hurr.html (last visited Mar. 15, 2008) [hereinafter *Global Warming and Hurricanes*].

Scientists have already observed that the intensity and duration of hurricanes have increased significantly around the world in recent decades, and attribute these changes to the warmer ocean temperatures associated with global warming.[87] The number of category four and five hurricanes has almost doubled over the past thirty years in the Atlantic, Pacific, and Indian Oceans, and these changes cannot be supported by natural variability or cycles alone.[88] Storms are growing in intensity because more energy is available to them from the warmer water,[89] and because a warmer atmosphere can hold more water vapor, leading to more intense rainstorms.[90] The economic loss from severe weather events has soared from $3.9 billion per year in 1950 to more than $40 billion per year in the 1990s, "despite significant efforts to fortify infrastructure and enhance disaster preparedness."[91]

More and more people are living in coastal areas, despite their increased vulnerability to storm surges and erosion. Almost one-quarter of the world's population lives on land 100 feet above sea level or less. This means at least one billion people are vulnerable to a sudden sea level rise from severe weather events.[92] More than sixty percent of Florida's population lives within ten miles of the coast, in the areas most susceptible to hurricane damage.[93] Again, the impact of a hurricane would be devastating to Florida's economy, which lost $3.2 million per day when the Florida Keys were closed after Hurricane Georges.[94] Moreover, the sixty-two Superfund sites[95] along the Gulf of Mexico threaten to contaminate public waters as a result of a storm surge.[96]

The combination of increased population and coastal development and increased sea levels makes hurricanes much more destructive and costly even if storms remain at the same level of intensity in the future.[97] By the end of the century, the combination of sea level rise and increased storm activity could

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[87] UNFAVORABLE TIDE, *supra* note 65, at 44.

[88] *Id.* The Red Cross has even been convinced to include climate change on its agenda, recognizing that climate change promises to increase the severity of disasters that it responds to. Mark Hertsgaard, *Adapt or Die*, THE NATION, May 7, 2007.

[89] *Global Warming and Hurricanes*, *supra* note 86.

[90] Titus, *Transportation*, *supra* note 66, at 3.

[91] Ferrey, *supra* note 21, at 121.

[92] Michael Kahn, *Sudden Sea Level Surges Threaten 1 Billion*, REUTERS, Apr. 20, 2007, *available at* http://www.reuters.com/article/sciencenews/idUSLAU97720220070419.

[93] VANISHING SHORES, *supra* note 49, at 2.

[94] SOUTH FLORIDA, *supra* note 39, at 7.

[95] Congress began the Superfund Program in 1980 in an effort to clean up the nation's uncontrolled hazardous waste sites. Under the Superfund program, the EPA works closely with communities, responsible parties, scientists, and government authorities to identify hazardous waste sites, test the conditions of the sites, formulate clean up plans, and clean up the sites. *See* 42 U.S.C. §§ 9601-9675 (2006); Environmental Protection Agency, Superfund Frequent Questions, http://epa.custhelp.com/cgi-bin/epa.cfg/php/enduser/std_alp.php (last visited Mar. 15, 2008).

[96] *See* HAUSERMAN, *supra* note 24, at 9.

[97] UNFAVORABLE TIDE, *supra* note 65, at 44.

cause megafloods that usually hit North America once every hundred years to occur once every three or four years.[98]

The 2004 tsunami in the Indian Ocean and Hurricane Katrina in 2005 demonstrate the devastating impact sudden sea level surges can have on coastal residents.[99] Weather disasters result not only in death, injury, and displacement of people, but destroy agriculture through winds, heavy precipitation, and increased salinization, pollute groundwater, spread disease through disrupted sewer systems, and damage social infrastructure.[100] A 100-foot surge in Florida would leave the whole state covered "except for a little plateau area."[101] With storm activity becoming more intense, a surge of this size is not unthinkable.

Higher seas already threaten human life and property; the added stress of increased storm activity makes taking action now even more imperative. A combination of preventing sea level rise by decreasing the concentration of GHGs in the atmosphere, mitigating the unavoidable damages from rising seas, and adapting to changing conditions is needed to protect residents and property in coastal areas from total devastation.

II. PREVENTION OF SEA LEVEL RISE

Although scientists agree that the full effects of current atmospheric concentrations of carbon dioxide and other GHGs on sea levels will take decades to reach their peak, the worst-case scenario can be avoided by curbing GHG emissions and removing them from the atmosphere now.[102] Complete melting of the Greenland and Antarctic ice sheets could increase sea levels by thirteen to twenty feet,[103] enough to completely submerge South Florida.[104] Scientists consider it unlikely that such widespread melting will occur in the twenty-first century;[105] however, under current policies of climate change and sustainable development, global GHG emissions will continue to increase,[106] a

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[98] The Associated Press, *Many Big Cities Face Sea-Level Threat*, Mar. 28, 2007, *available at* http://www.floridaclimatechange.com/pressreleaseMany.asp.

[99] Kahn, *supra* note 92.

[100] JOSEPH SMITH & DAVID SHEARMAN, CLIMATE CHANGE LITIGATION: ANALYZING THE LAW, SCIENTIFIC EVIDENCE AND IMPACTS ON THE ENVIRONMENT, HEALTH AND PROPERTY 155 (2006).

[101] Kahn, *supra* note 92.

[102] An immediate reduction of 70% of current levels would be needed just to stabilize GHG levels, and even then global temperature would be expected to increase 0.1 degree Celsius per decade for several centuries. IPCC FAR WGI, *supra* note 1, at 17.

[103] Tim Appenzeller, *The Big Thaw*, NAT'L GEOGRAPHIC, June 2007, at 68.

[104] HAUSERMAN, *supra* note 24, at 21.

[105] Nicholls & Lowe, *supra* note 31, at 229. *But cf.* Appenzeller, *supra* note 103, at 64-69 (expressing concern over the rate of melting observed at the Greenland and Antarctic ice sheets and detailing feedback mechanisms that are accelerating the loss of ice).

[106] IPCC FAR WGIII, *supra* note 6, at 4.

policy that "few doubt . . . will take us beyond the point of no return."[107]

Considering the dire predictions for sea level rise and its effects, any attempt to curb GHG emissions is a step in the right direction. It makes little difference globally how or where reductions occur.[108] Preventing the full effects of global warming requires active reduction of GHG emissions as well as removing GHGs from the atmosphere through carbon sinks.[109] Pursuing these measures may reverse global warming and its effects as early as 2080,[110] with the largest benefits occurring long into the future.[111]

Many legal scholars and vulnerable groups have advocated the use of litigation as a method for curbing GHG emissions, encouraging the use of a variety of mechanisms in a myriad of forums.[112] As one scholar notes, "[e]very tragedy contains within it a crime or a lawsuit."[113] However, forcing climate change measures on unwilling states through litigation is extremely inefficient and, thus far, unsuccessful.[114] Efforts to curb emissions should be undertaken voluntarily by or between nations in recognition of the serious problem of global warming. These efforts should include mandatory GHG caps, strengthening local and state policies to reduce dependence on fossil fuels by promoting energy efficiency, renewable energy, and cleaner transportation options, and encouraging protection and creation of natural habitats that have a net use of carbon dioxide.

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[107] Appenzeller, *supra* note 103, at 61.

[108] GILLESPIE, *supra* note 4, at 299.

[109] Jacobs, *supra* note 11, at 112. The United Nations Framework Convention on Climate Change defines a "sink" as "any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere." Framework Convention on Climate Change art. 1(8), May 9, 1992, S. TREATY DOC. NO. 102-38, 1771 U.N.T.S. 107, *available at* http://unfccc.int/resource/docs/convkp/conveng.pdf.

[110] Nicholls & Lowe, *supra* note 31, at 235.

[111] *Id.* at 241.

[112] *See, e.g.*, Randall S. Abate, *Climate Change, the United States, and the Impacts of Arctic Melting: A Case Study in the Need for Enforceable International Environmental Human Rights*, 43A STAN. J. INT'L L. 3 (SYMPOSIUM ISSUE) (2007) (exploring prior attempts to regulate GHGs through litigation and assessing the viability of a claim for climate change damages as a violation of the Alien Tort Claims Act and international human rights doctrines); David A. Grossman, *Warming Up To a Not-So-Radical Idea: Tort-Based Climate Change Litigation*, 28 COLUM. J. ENVTL. L. 1, 3 (2003) (advocating climate change lawsuits based on theories of products liability and public nuisance).

[113] Culley, *supra* note 22, at 107.

[114] Litigation techniques raise complicated questions of substantive law, as well as standing to sue and causation. *See, e.g.*, Blake R. Bertagna, Comment, *"Standing" Up for the Environment: The Ability of Plaintiffs To Establish Legal Standing To Redress Injuries Caused by Global Warming*, 2006 BYU L. REV. 415 (2006); Grossman, *supra* note 112, at 22-28 (identifying lack of judicial authority and competence to deal with climate change issues, the extensive financial resources of potential defendants, and the economic dependence on environmentally-harmful activities as barriers to successful environmental tort claims); McGee, *supra* note 42 (attempting to identify an appropriate forum for climate change litigation).

Given its vulnerability to sea level rise, Florida should take immediate action to strengthen existing measures designed to decrease atmospheric carbon and implement new ones. The state currently ranks fifth in the nation in terms of its carbon dioxide emissions from fossil fuel combustion, most of which comes from electric power plants and motor vehicles.[115] Moreover, Florida's energy use is rising nearly twice as fast as the nation as a whole[116] and the state is almost completely dependent on imports to fund its energy requirements.[117]

A. Achieving Emissions Reductions

The IPCC reports that there is "substantial economic potential" for the mitigation of global GHG emissions that could offset the projected growth of global emissions or reduce emissions below current levels.[118] Despite general acknowledgement that decreasing GHG emissions results in economic gain,[119] the federal government has thus far declined to implement any mandatory GHG reduction scheme, instead relying entirely on voluntary measures.[120] However, the Senate recently recognized the need to respond to climate change and approved a resolution declaring that Congress should enact mandatory, market-based limits on GHG intensity.[121] Although not binding, this resolution represents the first time the Senate has acknowledged the need for GHG controls.[122] In the meantime, many states have implemented their own GHG control schemes, focusing on industry, transportation, and household emissions.

Since burning oil is the primary source of carbon dioxide emissions, it is essential that steps be taken to curb this activity.[123] This can generally be achieved by capping GHG emissions, increasing energy efficiency, and creating and utilizing new energy sources. In fact, the Natural Resources Defense Council predicts that, through a combination of these methods, the United States

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[115] UNFAVORABLE TIDE, *supra* note 65, at 47.

[116] *Id.*

[117] Florida Climate Action Partnership, S.B. 2446, 109th Sess., preamble (2007), 2007 Bill Text FL S.B. 2446 (LEXIS).

[118] IPCC FAR WGIII, *supra* note 6, at 9.

[119] *See, e.g.*, RABE, *supra* note 25 (detailing the economic benefits that prompt many states to adopt climate change policies).

[120] The Supreme Court recently described the President George W. Bush's "comprehensive approach" to climate change as involving "additional support for technological innovation, the creation of non-regulatory programs to encourage voluntary private-sector reductions in greenhouse gas emissions, and further research on climate change — *not actual regulation*." Massachusetts v. EPA, 127 S. Ct. 1438, 1451 (2007) (emphasis added). Current U.S. climate change policy can be found in USA: ENERGY NEEDS, CLEAN DEVELOPMENT, AND CLIMATE CHANGE (2006), http://www.state.gov/documents/organization/75455.pdf.

[121] S. Res. 866, 109th Cong., 151 CONG. REC. S7033 (2005).

[122] WOOLEY & MORSS, *supra* note 5, at § 6:35.

[123] Clare Breidenich et al., *The Kyoto Protocol to the United Nations Framework Convention on Climate Change*, 92 AM. J. INT'L L. 315, 317 (1998).

can reduce its oil dependence by more than three million barrels a day in ten years, and more than eleven million barrels a day by 2025.[124]

1. Putting a Price on Carbon

Current fuel prices do not accurately reflect the full costs of releasing GHGs into the atmosphere, effectively subsidizing the use of GHG-producing activities. Internalizing these costs through a carbon tax would encourage consumers and industry to use energy sources that are less expensive in terms of their environmental impact.[125] The costs of GHG emissions increase even further when the benefits of reducing emissions to health, energy security, and agricultural production are considered.[126]

Implementing a monitoring and assessment program is an important first step in raising public awareness about the production and effects of GHG emissions and developing a starting point on which to base GHG reduction schemes. In the past, such programs have led to mandated reductions in air pollution emissions.[127] At least thirty-nine states have carried out GHG inventories, which may include identification of potential opportunities to reduce state emissions.[128] California, New Hampshire, New Jersey, Texas, and Wisconsin have already created voluntary GHG emission registries to help companies receive retroactive credit for emissions reductions if they are mandated.[129]

After emission levels are determined, carbon may be taxed through a societal benefit charge. Some places, such as the state of New Jersey, have imposed a "tax" on GHG-emitting activities to discourage participation.[130] The revenues generated by these charges are used to fund energy efficiency or renewable

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[124] ANN BORDESTSKY ET AL., SECURING AMERICA: SOLVING OUR OIL INDEPENDENCE THROUGH INNOVATION 13 (2005), *available at* http://www.nrdc.org/air/transportation/oilsecurity/plan.pdf.

[125] IPCC FAR WGIII, *supra* note 6, at 19. However, this may cause strife in oil-producing countries. For example, the United Arab Emirates told the European Union that it would consider the imposition of a carbon tax as paramount to a declaration of war. GILLESPIE, *supra* note 4, at 216.

[126] *See* IPCC FAR WGIII, *supra* note 6, at 12 (predicting that the co-benefits of reduced air pollution as a result of actions to reduce GHG emissions will offset "a substantial fraction" of mitigation costs).

[127] For example, the Emergency Planning and Community Right-to-Know Act of 1986 established a reporting requirement for certain types of pollution that led to development of the air toxics provisions of the Clean Air Act. *See* 42 U.S.C. § 11023 (2007); WOOLEY & MORSS, *supra* note 5, at § 6:25.

[128] Laura Kosloff & Mark Trexler, *State Climate Change Initiatives: Think Locally, Act Globally*, 18 NAT. RESOURCES & ENV'T. 46, 47 (2004).

[129] WOOLEY & MORSS, *supra* note 5, at § 6:32.

[130] For more information, see New Jersey Incentives for Renewable Energy, *Societal Benefits Charge*, http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=NJ04R&state=NJ&CurrentPageID=1 (last visited Mar. 15, 2008).

energy projects.[131]

The most effective way to curb GHG emissions may be through a mandatory GHG reduction scheme coupled with an emissions trading system.[132] This system has been used successfully in the United States to combat air pollution and acid rain.[133] Under an emissions trading scheme, each polluting source is given a quota of polluting units, and may meet the standard by improving efficiency, purchasing emissions credits from other sources, or implementing offset projects.[134] The system creates a double incentive for companies to reduce emissions (1) by imposing extra costs on those who fail to abate sufficiently, and (2) by rewarding sources that emit less than they are allowed by permitting them to sell their unused credits.[135] Allowing international trading lessens the cost of unused credits even further by expanding the market.[136]

In the absence of a nation-wide scheme, several states have recognized the importance and usefulness of this option.[137] For example, the Regional Greenhouse Gas Initiative ("RGGI") has implemented a cap-and-trade program limiting total emissions of GHGs from power plants in its seven member states.[138] The program, modeled after the Environmental Protection Agency's

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[131] A list of these projects can be found in N.J. STAT. ANN. § 48:3-60 (West 2007).

[132] The classic tale of the "tragedy of commons" suggests that a mandatory system is integral to full participation. *See* Kirsten H. Engel, *Mitigating Global Climate Change in the United States: A Regional Approach*, 14 N.Y.U. ENVTL. L.J. 54, 60 (2005). However, although the United States has done very little to curb its GHG emissions since signing, but refusing to ratify, the Kyoto Protocol, many states are taking their own actions. *Id.* at 55 n.5, 62 (suggesting, as plausible explanations for the anti-reluctance of states to enact climate change policies: "political advantages from state leadership on an international issue which the federal government is mostly ignoring; competitive advantages over other regions associated with the early adoption of regulations that may soon become widespread; concern over the public health and environmental impacts of climate change; and prior success in influencing national environmental policy [as well as] perceived cost savings associated with climate policy and . . . other expected co-benefits, such as a reduction in traffic congestion, reduced maintenance and operating costs from more energy-efficient technologies, reduced air pollution, and a decrease in the volume of municipal solid waste generated.").

[133] GILLESPIE., *supra* note 4, at 311; But *see id.* (noting complexities likely to arise in an emissions trading scheme, including issues regarding ecologically sensitive hot spots, when to implement the system, and how to enforce it).

[134] *Id.*

[135] *Id.*

[136] *Id.* at 312.

[137] *See generally* Kevin L. Doran, *Can the U.S. Achieve A Sustainable Energy Economy from the Bottom-Up? An Assessment of State Sustainable Energy Initiatives*, 7 VT. J. ENVTL. L. 3 (2005) (surveying major state and regional clean energy and climate change initiatives and analyzing their effectiveness in securing a sustainable U.S. energy economy); Engel, *supra* note 132 (discussing the benefits and limitations of regional initiatives to curb climate change). In addition, The European Union adopted an emissions trading regime in 2005 initially regulating emissions from five energy-intensive industries in twenty-five countries. *See* GILLESPIE, *supra* note 4, at 315.

[138] The RGGI states are Connecticut, Delaware, Maine, Maryland, New Hampshire, New Jersey, New York, and Vermont. WOOLEY & MORSS, *supra* note 5, at § 6:33 n.1. *Id.*

acid rain cap-and-trade program, allows the regulated plants to trade carbon dioxide allowances to achieve the necessary emissions reductions.[139] Similar systems have been implemented in Massachusetts and New Hampshire,[140] and could be employed in Florida to reduce GHG emissions. Implementation of these state-wide or regional emissions trading systems are also beneficial in that they are likely to increase pressure on the federal government to enact a uniform, national program and result in more widespread emission reductions.[141]

2. Alternative Fuels and Technology

Non-carbon-based energy sources have been investigated for decades, and successful attempts have been achieved using wind, solar power, tidal forces, nuclear technology, and biomass.[142] Many states and nations have implemented renewable energy portfolios that require businesses and industries to get a specified percentage of their electricity from renewable sources,[143] and the IPCC predicts that by 2030, renewable energy sources could account for thirty to thirty-five percent of all electricity production.[144] Florida's legislature is currently considering a bill calling for fifty percent of energy production in renewable energy.[145]

An important area for reductions is the transportation sector, which consumes twenty-seven percent of all commercial energy in the United States.[146] Reducing emissions in this sector is as simple as substituting electricity, hydrogen fuel, or biodiesel for traditional gasoline.[147] Technology can also be modified to use fuel more efficiently by adding substances or changing the temperature, design, or airflow.[148] Strategic land use planning and development

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[139] *Id.* at § 6:33.

[140] *See* 310 MASS. CODE REGS. 7.29(5)(a) (2007); N.H. REV. STAT. ANN. § 125-O:1-10 (2007).

[141] *See* Engel, *supra* note 132, at 56.

[142] GILLESPIE, *supra* note 4, at 337. Unfortunately, the widespread use of low-carbon technologies may take decades, even if investment is made particularly attractive through government incentives. IPCC FAR WGIII, *supra* note 6, at 18.

[143] California, Denmark, Germany, and India have all created specific goals to increase the percentage of energy used from renewable sources. GILLESPIE, *supra* note 4, at 338.

[144] IPCC FAR WGIII, *supra* note 6, at 13. Wind-generated energy may be particularly effective; at current growth rates, wind could supply ten to twelve percent of the earth's energy by 2020, and the whole earth could be powered with a farm the size of Saudi Arabia. GILLESPIE, *supra* note 4, at 338-39.

[145] S. 996, 109th Leg., Reg. Sess. (Fla. 2007); S.2666, 109th Leg. Sess.(Fla. 2007); H. 313, 109th Leg. Reg. Sess. (Fla. 2007); Stephen Majors, *Florida Considers Renewable Energy Bill*, ASSOCIATED PRESS, Mar. 28, 2007 (on file with author).

[146] GILLESPIE, *supra* note 4, at 43; *see also* Massachusetts v. EPA, 127 S. Ct. 1438, 1457 (2007) ("Considering just emissions from the transportation sector . . . the United States would still rank as the third-largest emitter of carbon dioxide in the world.").

[147] *See* GILLESPIE, *supra* note 4, at 348-49.

[148] *Id.* at 347. Pollutants may even be captured post-combustion but before emission. *Id.*

may also result in lower vehicle emissions. Mixed-use policies, which mix commercial and residential areas together, and compact development can reduce the vehicle miles traveled to run errands and commute to work.[149]

California was the first state in the United States to set limits on carbon dioxide emissions from motor vehicles. Passed in 2002, A.B. 1493 mandates carbon pollution standards for vehicles in model years 2009 and beyond.[150] These standards are expected to achieve a thirty percent reduction in GHGs from new vehicles once they are fully implemented in 2015.[151] Sixteen states, including Florida, have either adopted or plan to adopt these standards.[152] The U.S. Supreme Court has also recently ruled that the federal government has the power to regulate automobile GHG emissions as "air pollutants" under the Clean Air Act,[153] maintaining that the EPA's refusal to do so "presents a risk of harm . . . that is both 'actual' and 'imminent.'"[154]

Investing in alternative energy sources has many additional advantages. The resulting energy security cannot be stressed enough, especially for a state like Florida that depends almost entirely on foreign oil for its energy needs.[155] Promoting and using alternative fuels and technology also increases the public benefit through research and development opportunities.[156] These practices improve the general quality of life by increasing innovation and creating jobs.[157] Similarly, emissions reductions in the transportation sector often simultaneously

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[149] IPCC FAR WGIII, *supra* note 6, at 12-13; SOUTH FLORIDA, *supra* note 39, at 2. The same amount of residential, office, and retail space covers more than twice the land area when built in the suburbs rather than an urban location. SOUTH FLORIDA, *supra* note 39, at 6.

[150] CAL. HEALTH & SAFETY CODE § 43018.5 (Deering 2007). Note that A.B. 1493 is not yet in effect because the EPA has failed to grant the necessary waiver allowing California to enact tougher-than-federal automobile emission standards. *California to Bush Administration: Stop Stalling! State Sues U.S. EPA Over Tailpipe Emissions Waiver*, VERDEXCHANGE NEWS, Nov. 8, 2007, http://www.verdexchange.org/node/57 [hereinafter *Stop Stalling!*]. For a discussion regarding the likelihood of California receiving a waiver for A.B. 1493, see also Sara A. Colangelo, *The Politics of Preemption: An Application of Preemption Jurisprudence and Policy to California Assembly Bill 1493*, 37 ENVTL. LAW 175 (2007).

[151] WOOLEY & MORSS, *supra* note 5, at § 6:32.

[152] These states include Arizona, Colorado, Connecticut, Florida, Maine, Maryland, Massachusetts, New Jersey, New Mexico, New York, Oregon, Pennsylvania, Rhode Island, Utah, Vermont, and Washington. *Stop Stalling!*, *supra* note 150.

[153] Massachusetts v. EPA, 127 S. Ct. 1438, 1462 (2007) ("Under the clear terms of the Clean Air Act, EPA can avoid taking further action only if it determines that greenhouse gases do not contribute to climate change or if it provides some reasonable explanation as to why it cannot or will not exercise its discretion to determine whether they do.").

[154] *Id.* at 1455.

[155] *See* Florida Climate Action Partnership, S. 2446, 109th Sess., preamble (2007), 2007 Bill Text FL S.B. 2446 (LEXIS); *see also* Gary C. Bryner, *Challenges in Developing a Diverse Domestic Energy Portfolio: Integrating Energy and Climate Policy in the Western United States*, 15 N.Y.U. ENVTL L.J. 73 (2007).

[156] IPCC FAR WGIII, *supra* note 6, at 17.

[157] *Id.*

address problems of traffic congestion and air pollution.[158]

Florida already encourages many of these methods and has recently taken steps to strengthen these initiatives. The Florida Energy Commission is currently charged with developing recommendations for legislations to establish state energy policy, consistent with policies of reliable and diverse energy supply, goals for growth management, the environment, and public health, and the development of alternative energy technologies and alternative fuels.[159] Solar energy is a constant and plentiful energy source in the Sunshine State, and the state provides rebates for individuals that install solar photovoltaic systems that meet the eligibility requirements up to $20,000 for a residence and $100,000 for commercial property.[160] Florida's new policy requires power companies to produce at least twenty percent of their electricity from renewable power.[161] In addition, the state provides matching grants and other incentives for activities that stimulate investment in, enhance the market for, and promote statewide utilization of renewable energy technology.[162] Moreover, Florida is a major agricultural producer, and should take advantage of the fact that it is capable of producing large quantities of biofuels from biomass to replace fossil fuels.[163]

3. Energy Efficiency

A third way to reduce carbon dioxide emissions and prevent catastrophic sea level rise is to increase energy efficiency. Efficiency involves maintaining the same unit of output, without reducing quality or performance, while simultaneously reducing the amount of energy required to produce it, thereby reducing energy demand.[164] The IPCC estimates that efficiency gains can reduce GHG emissions in the building sector by ten to thirty percent in thirty

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[158] *Id.* at 13.

[159] FLA. STAT. § 377.901(5), (7) (2007).

[160] *Id.* at § 377.806. Currently, only 0.01% of all solar energy that reaches the earth is used. Ferrey, *supra* note 21, at 135.

[161] *See* Jim Loney, *Florida To Introduce Tough Greenhouse Gas Targets*, REUTERS, July 12, 2007, *available at* http://www.enn.com/climate/article/6914.

[162] FLA. STAT. § 377.802 (2007). For more information, see Florida Solar Energy Center, *New Energy Bill Moves Florida Towards Energy Independence*, http://www.fsec.ucf.edu/en/media/enews/2006/2006-03_Energy-bill.htm (last visited May 29, 2007).

[163] Florida Climate Action Partnership, S. 2446, 109th Sess., preamble (2007), 2007 Bill Text FL S.B. 2446 (LEXIS). For example, a recent report notes that there is enough prairie grass, crop residue, papermaking waste, and cattle manure — "matter that generally is considered worthless" — to generate 1.3 billion gallons of ethanol. *Investing in biomass fuels will pay off for Wisconsin*, FOND DU LAC REP., May 2, 2007, *available at* http://www.wapa.gov/es/greennews/2007/may1407.htm. Unfortunately, Florida currently lacks the infrastructure to convert entirely to a biofuel system. Florida Climate Action Partnership, S. 2446, preamble.

[164] GILLESPIE, *supra* note 4, at 328.

years while obtaining a net economic benefit.[165]

Increased efficiency translates into economic savings, which will encourage consumers to pursue such efforts regardless of the environmental benefits or their stance in the climate change debate.[166] As a result, "green buildings" are springing up around the world. For example, the Bank of America is currently building a 945-foot building in the heart of Manhattan that will use re-circulated heat and natural gas to produce some of its own energy.[167] Higher ceilings and insulating glass will stabilize indoor temperatures and maximize available sunlight to decrease energy needs.[168] Ice will be produced in the evenings, when energy demands are lowest, and used to cool the building during the day, when power plants run at peak capacity.[169] These buildings cost only about five percent more to construct, but quickly exceed that outlay in energy savings.[170]

The Florida legislature can decrease energy demand by continuing to increase energy efficiency programs and incentives with updated building codes and appliance standards.[171] These methods are easily implemented, cost effective, and result in significant savings to energy consumers in addition to reducing GHG emissions. For example, the Florida Department of Environmental Protection encourages consumers to conserve energy through simple measures, such as switching to compact fluorescent light bulbs and unplugging appliances when not in use.[172]

B. Reducing Greenhouse Gases Through Carbon Sequestration

In addition to curbing emissions, carbon dioxide can be removed from the atmosphere, eliminating its warming effect, through the use of carbon sinks. Both oceanic and terrestrial ecosystems naturally extract significant amounts of carbon dioxide from the atmosphere and store it in plant life.[173] Simply halting deforestation could decrease carbon dioxide emissions by three billion tons per

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[165] IPCC FAR WGIII, *supra* note 6, at 13.

[166] GILLESPIE, *supra* note 4, at 328.

[167] Jeffrey Kluger, *What Now For Our Feverish Planet?*, TIME, Mar. 29, 2007, *available at* 2007 WLNR 5967005.

[168] *Id.*

[169] *Id.* (describing similar buildings in San Francisco and Gaungzhou, China, that are designed to run more efficiently and on clean energy).

[170] *Id.*

[171] The state promotes energy conservation and efficiency by providing rebates, grants, and tax incentives through the Florida Renewable Energy Technologies & Energy Efficiency Act. FLA. STAT. §§ 366.80-.85, 403.519 (2007).

[172] A complete list of these suggestions is available at Florida Department of Environmental Protection, *Energy Conservation Tips*, http://www.dep.state.fl.us/energy/energy_tips.htm#office (last visited Mar. 15, 2008).

[173] In fact, almost two-thirds of atmospheric carbon is stored in forests. Ferrey, *supra* note 21, at 118.

year at a relatively low cost.[174] Natural habitats, such as wetlands, grasslands, and forests, that have a net use of carbon dioxide should be protected and restored.

In the ocean, phytoplankton absorbs carbon dioxide dissolved in the water, using it to create food and oxygen.[175] As a result, the ocean can absorb more carbon dioxide from the air.[176] When phytoplankton dies, it sinks to the bottom of the ocean where it becomes locked in sediment and is removed from the carbon cycle.[177] One researcher has proposed exploiting the carbon-dioxide storing capacity of phytoplankton by pumping cold, nutrient water from the deep sea.[178] This would encourage algae to bloom in shallower water and absorb more carbon dioxide from the atmosphere.[179]

Together, vegetation and soils store almost 2,500 gigatons of carbon dioxide.[180] In fact, almost fourteen percent of the earth's organic carbon is stored in frozen peat beneath tundra. [181] This ice contains 400 gigatons of methane – 3,000 times the amount currently present in the atmosphere.[182] Thus, preservation of wetlands is important both as a carbon sequestration technique and as a buffer against storm damage. Reforestation, in addition to halting deforestation, is also an effective method for increasing carbon storage in plant life.[183] Planting tress can also provide shade from the sun, with the potential to reduce energy budgets by thirty to forty percent.[184]

Carbon levels in soils depend on inputs including crop residue and organic additions, and outputs including carbon losses and decomposition.[185] Therefore, the carbon storage capacity of forests, cropland, and grazing land can be increased through proper management.[186] Preventing soil erosion, reducing the number of trips over a field, and leaving crop residues all sequester carbon in

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[174] GILLESPIE, *supra* note 4, at 40. This represents about 50% of the total global mitigation potential identified by the IPCC. IPCC FAR WGIII, *supra* note 6, at 14.

[175] GILLESPIE, *supra* note 4, at 38.

[176] *Id.*

[177] *Id.*

[178] Akok Jha, *Ocean Pumps 'Could Cut Carbon Dioxide,'* GUARDIAN UNLIMITED, Dec. 14, 2006, *available at* http://www.guardian.co.uk/environment/2006/dec/14/usnews.climatechange.

[179] *Id.* The method is also purported to increase fish stocks and prevent hurricanes. *Id.*

[180] GILLESPIE, *supra* note 4, at 39.

[181] *Id.* at 41. 400 billion tons of methane are stored in permafrost, 90% of which is likely to melt by 2100. Brad Arnold, *Global Warming and Melting Methane Hydrate*, THE PILOT-INDEPENDENT, May 3, 2007 (on file with author). A release of only 30 billion tons of methane would be the equivalent of doubling the current concentrations of carbon dioxide. *Id.*

[182] John Atcheson, *Methane Burps: Ticking Time Bomb*, BALTIMORE SUN, Dec. 15, 2004, *available at* http://www.energybulletin.net/3647.html.

[183] GILLESPIE, *supra* note 4, at 40.

[184] SOUTH FLORIDA, *supra* note 39, at 6.

[185] GILLESPIE, *supra* note 4, at 386 n. 78.

[186] *See id.* at 387.

soils while simultaneously improving soil quality.[187] The use of alternative agricultural practices can also preserve carbon levels in soil, and these methods are being promoted in many Midwestern states.[188]

A more immediate solution may be to store carbon underground, the same way that radioactive waste is stored.[189] The earth has many safe, stable places to store unwanted materials.[190] For example, carbon could be pumped into chambers emptied from natural gas extraction, where, in many instances, the necessary equipment is still around and could easily be reconfigured from extraction to injection.[191] Researchers also propose pumping it into porous sediment below the deep ocean trenches.[192] The U.S. Department of Energy is already funding several research projects to test these sequestration technologies.[193]

Given the widespread and potentially devastating effects of sea level rise, Florida should adopt a comprehensive approach that promotes energy efficiency, supports aggressive biofuel and renewable energy programs, and enacts a societal benefit charge on GHG emissions. Diversifying climate change initiatives will be most efficient and effective at preventing catastrophic sea level rise.[194] Unfortunately, some sea level rise is inevitable, and additional steps must be taken to mitigate its effects.

III. MITIGATION OF SEA LEVEL RISE

While the long-term solution to sea level rise is to reduce the levels of GHGs in the atmosphere, to the extent that sea level is rising and will continue to do so,

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[187] *Id.* at 386. Note that there is no universal practice applicable to all agricultural systems; practices should be developed taking into account the unique characteristics and use of each individual system. IPCC FAR WGIII, *supra* note 6, at 14.

[188] GILLESPIE, *supra* note 4, at 386. Illinois, Nebraska, Oklahoma and Kansas have all enacted laws to encourage reforestation and soil carbon enhancement programs. Kosloff & Trexler, *supra* note 128, at 47.

[189] IPCC FAR WGIII, *supra* note 6, at 13; Kluger, *supra* note 167.

[190] Kluger, *supra* note 167.

[191] *Id.*

[192] Kevin Bullis, *Storing Carbon Dioxide under the Ocean: A Safe, High-Capacity Method Could Make Carbon Sequestration More Practical*, MIT TECH. REV., Aug. 8, 2006, *available at* http://www.technologyreview.com/Energy/17274/.

[193] For more information about geologic, terrestrial, biological and chemical sequestration techniques, see U.S. Department of Energy, *Carbon Sequestration R&D Overview*, http://www.fossil.energy.gov/programs/sequestration/overview.html (last visited Mar. 15, 2008).

[194] Comprehensive approaches have been adopted by many states as well as the West Coast Governors' Global Warming Initiative and the U.S. Mayors Climate Protection Agreement. For more information regarding these groups' initiatives and participants, see West Coast Governor's Global Warming Initiative, http://www.ef.org/westcoastclimate/ (last visited Mar. 15, 2008); U.S. Mayors Climate Protection Agreement, http://www.ci.seattle.wa.us/mayor/climate/default.htm#who (last visited Mar. 15, 2008) (reporting that as of March 15, 2008, more than 800 cities representing all 50 states have signed on).

the destructive impact can be minimized. As one commentator notes, "[a]t this point we must accept that the battle to prevent global warming is over; now, the race to survive it has begun."[195] The best approach to sea level rise may be to prepare for the inevitable, rather than try to force change. These steps include both mitigation and adaptation to the unavoidable impacts of sea level rise. Efforts may include elevating or re-nourishing land, building structures to keep out rising seas, adopting land management practices that prevent risky development while preserving wetlands through environmental impact assessments, implementing water management schemes, and in some cases, completely abandoning of at-risk property.

A. Making Informed Decisions

Environmental impact assessments ("EIAs") are essential to both mitigation and adaptation techniques because they require developers to consider the consequences of their projects on the environment. These statements allow for long-term contemplation of the cumulative impacts of development along with the possible effects of sea level rise by requiring that the adverse and beneficial impacts of projects and their alternatives be set forth before proceeding with any action likely to significantly affect the environment.[196] The United States currently requires EIAs only for "major Federal actions significantly affecting the quality of the human environment."[197] However, EIAs should be used for *all* new development projects because they protect people and property, while allowing for immediate fixes without the lengthy political process of creating or revising the law.

Before purchasing property, private buyers should assess the risks posed to them by climate change and sea level rise.[198] A service is already available to consumers that lists over fifty risk factors of a particular property, including those related to sea level rise, temperature, drought, flood, and wildfire, in addition to those expected to worsen with warming temperatures such as

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[195] Hertsgaard, *supra* note 88.

[196] In the United States, government projects are required to prepare environmental impact assessments under the National Environmental Policy Act of 1969, 42 U.S.C. § 4332(2)(C) (2006). Note that NEPA describes the report as an environmental impact statement, or EIS. *Id.* NEPA was enacted to force agencies to identify and consider the environmental consequences of their projects before proceeding. *See* Mary K. Fitzgerald, Comment, *Small-Handles, Big Impacts: When Should the National Environmental Policy Act Require an Environmental Impact Statement?* 23 B.C. ENVTL. AFF. L. REV. 437, 440 (1996).

[197] 42 U.S.C. § 4332(2)(C).

[198] Consumers should be aware that declining coastal real estate values are likely a reflection of the increased risk along the shore resulting from the combination of higher sea levels and increased hurricane intensity. Patrick O'Driscoll, *Website Checks Your Home's Climate Change Risk*, USA TODAY, Apr. 9, 2007, *available at* http://www.usatoday.com/weather/climate/2007-03-28-climate-risk_N.htm.

disease, pollution, and industrial factors.[199] Researchers in Galveston, Texas recently developed a map of the area's geological hazards, prompting the city to consider adopting strict construction regulations in the high-risk areas to protect homebuyers, wetlands, wildlife, and recreational areas that attract tourists to the area.[200] Scientists have developed a similar model of the Australian coast in an attempt to determine which areas will be affected by climate change and sea level rise.[201] The program will help officials determine which roads and infrastructure need to be relocated before being submerged by rising sea levels storm surges.[202]

Climate change has been considered in the designs of coastal defense infrastructure projects in the Maldives and the Netherlands, and of the Confederation Bridge in Canada.[203] Potential climate change impacts have been integral to the design of a new urban village to be built north of London.[204] This village will not only be a low-carbon-energy user, but will attempt to avoid future problems from sea level rise by building flood protection into its design.[205] In addition, the Ministry of Water Resources in Bangladesh, one of the most vulnerable places on earth to global warming, recently agreed to incorporate climate change models into all future planning and decisions.[206] The state of Florida can similarly limit its risk to rising seas by assessing the threats of climate change to new development and re-construction projects and incorporating proper protection into their design.

B. Holding Back the Sea

Historically, property owners have erected various types of structures along the coastline to halt erosion, such as dikes and bulkheads.[207] In Florida, sea walls extend along fourteen to twenty percent of Florida's sandy beaches.[208] However, this method has several significant disadvantages. First, using these

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[199] *Id.*

[200] Harvey Rice, *Sinking the Case For Island Growth: A Map detailing Galveston Areas Not Geologically Sound For Development Has Its Supporters — And Its Skeptics*, HOUSTON CHRON., Mar. 18, 2007, *available at* 2007 WLNR 5126753.

[201] *Scientists Develop Model To Combat Sea Level Rise*, ABC NEWS, Apr. 10, 2007, *available at* http://www.abc.net.au/news/newsitems/200704/s1893553.htm.

[202] *Id.* Not surprisingly, the developer of the program urges that steps be taken as infrastructure is renewed, rather than waiting to react once the area is under water. *Id.*

[203] IPCC FAR WGII, *supra* note 52, at 19.

[204] Hertsgaard, *supra* note 82, at 102.

[205] *Id.*

[206] *Id.* Additionally, the city of Santa Cruz, California is reconsidering management of its river levees and water management strategies in light of projected sea level rise. Roger Sideman, *Santa Cruz Ahead Of Curve In Sea-Level Rise Preparations*, S.F. GATE, Apr. 2, 2007, *available at* http://sfgate.com/cgi-bin/article.cgi?f=/n/a/2007/04/02/state/n075650D74.DTL.

[207] VANISHING SHORES, *supra* note 49, at 1.

[208] HAUSERMAN, *supra* note 24, at 4.

structures successfully becomes progressively more difficult as sea levels rise.[209] The structural integrity of existing levees and seawalls is already threatened, notwithstanding the projected rise in sea level.[210] Second, the use of dikes and bulkheads prevents landward migration of wetlands, destroying a critical defense to storm surges, as well as depriving the public of recreational areas and damaging coastal habitats.[211]

Dikes will need to be elevated to prevent higher flood levels from overtopping them, and additional structural supports could be necessary to prevent erosion from undermining them from below.[212] At first, tide gates and check valves allow water to drain at low tide.[213] Later, pumps will be needed to remove excess water, and as sea levels continue to rise, even more water will have to be pumped to even more remote locations.[214] For example, officials in Tokyo acknowledge that their underground flood control system, capable of pumping 200 tons of water per second into the harbor, has reached its capacity.[215] Both the system and the city's sewage and drainage systems will need to be upgraded in response to rising sea levels.[216]

As an alternative, property owners are elevating existing structures in low-lying areas. Many communities on developed barrier islands are responding to sea level rise by bringing in fill to elevate the land.[217] Eight New Jersey towns on barrier islands have already signed agreements with the EPA pledging to prepare for the consequences of rising sea levels.[218] These towns see elevation as the only viable option, rejecting the possibility of building a dike or abandoning their property.[219] Bangladesh is also working to raise roads, wells,

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[209] Titus, *Transportation*, *supra* note 66, at 9.

[210] The Army Corps of Engineers recently announced that 122 major levee systems are "less than safe," and these levees will face even greater stresses as sea level rises. Hertsgaard, *supra* note 82, at 102.

[211] Note that the environmental consequences of doing so may be relatively minor in areas where wetlands have already been destroyed or severely restricted by coastal development. Titus, *Transportation*, *supra* note 66, at 3.

[212] GREENHOUSE EFFECT AND SEA LEVEL RISE: A CHALLENGE FOR THIS GENERATION 148 (Michael C. Barth & James G. Titus, EDS., 1984), *available at* http://www.epa.gov/climatechange/effects/downloads/greenhouse.pdf. Moreover, dikes will need to be elevated by more than the projected sea level rise; the impact of a dike failure is far greater when the sea is ten feet above a town than when it is only two feet above. Titus, *Transportation*, *supra* note 66, at 9.

[213] Titus, *Transportation*, *supra* note 66, at 9.

[214] *Id.* Dikes may also pose additional risks because rainwater flooding can worsen as the barriers that keep the seawater out also keep the rainwater in. *Id.* at 8.

[215] Hertsgaard, *supra* note 82, at 102.

[216] *Id.*

[217] Titus, *Transportation*, *supra* note 66, at 6. Residents are motivated, at least in part, by lower flood insurance rates. HEALTH AND EFFECTS, *supra* note 43.

[218] Titus, *Transportation*, *supra* note 66, at 6 n.i.

[219] *Id.*

and houses above the level of the last major flood. [220] An advantage of this approach is that people need not anticipate long-term sea level rise, but only keep up with it as it occurs; in theory, this could be a never-ending process.[221] In addition, elevating land surfaces allow beaches and wetlands to survive while protecting private property.[222]

Similarly, beach nourishment projects attempt to counteract erosion by periodically transporting sand onto eroding beaches. In 2005, state and federal governments spent almost $200 million on restoration programs for Florida's beaches and dunes.[223] It would cost Florida approximately $5.8 billion per year to replenish sand beaches lost to a three-foot rise in sea level.[224] Moreover, this tactic provides false security to adjacent landowners and simply prolongs the inevitable loss of the beach.

C. Wetland Protection

Protecting wetlands and coastal features such as beaches, dunes, and barrier islands, and allowing them to migrate landward will mitigate some of the damages sea level rise is expected to cause. Wetlands filter runoff, recharge drinking water supplies, and help maintain healthy estuaries.[225] In addition, wetlands and barrier islands act like speed bumps, absorbing the force of incoming storm surges so that they are weaker when they reach inland.[226] Despite the near total devastation of the Mississippi Gulf Coast by Hurricane Katrina, nearby barrier islands actually protected pockets of homes and businesses.[227] Recognizing the importance of the islands as protection from storms, officials are considering towing concrete and storm debris into the ocean to rebuild the islands, which have been slow to regenerate themselves.[228]

Historically, coastal and wetland systems were able to keep pace with sea level, migrating inland with the sea.[229] However, because sea level rise is

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[220] Hertsgaard, *supra* note 82, at 102.

[221] Titus, *Transportation*, *supra* note 66, at 6, 9.

[222] Titus, *Restructure*, *supra* note 78, at 733, 740.

[223] HAUSERMAN, *supra* note 24, at 4. In Miami alone, renourishment projects cost $650,000 per year. SOUTH FLORIDA, *supra* note 39, at 11.

[224] UNFAVORABLE TIDE, *supra* note 65, at 17. Another study projects the cumulative cost of sand replenishment to protect Florida's coast from a 20-inch rise in sea level by 2100 as between $1.7 and $8.8 billion. CLIMATE CHANGE AND FLORIDA, *supra* note 29, at 3.

[225] HAUSERMAN, *supra* note 24, at 5.

[226] Hertsgaard, *supra* note 82, at 102.

[227] GULF RESTORATION NETWORK & SIERRA CLUB, THE SCHOOL OF BIG STORMS: THE HIGH COST OF COMPROMISING OUR NATURAL DEFENSES AND THE BENEFITS OF PROTECTING THEM 12 (2006), *available at* http://www.sierraclub.org/gulfcoast/downloads/bigstorm.pdf [hereinafter SCHOOL OF BIG STORMS].

[228] *Id.* at 13. The regeneration of barrier islands on the Gulf Coast has been undermined by the nearby dredging of navigational channels. *Id.*

[229] SOUTH FLORIDA, *supra* note 39, at 4.

occurring at an accelerated rate, these systems do not have time to adapt. Experts agree that mangroves can only withstand a sea level rise of about three-eighths of an inch per century.[230] With sea level rising more than a foot each century in Florida, drastic changes in mangrove swamps are expected over the next 100 years.[231] A 1.6-foot rise in sea level would cause devastating losses of mangroves in southwest Florida.[232] Increased coastal development further prohibits migration by halting the wetlands in their tracks.[233]

Because the barrier islands are such an important and effective protector of the coastline from tropical storms, communities should fully analyze the effects that development and other activity will have on them.[234] Many states have adopted policies to ensure that beaches, dunes, and wetlands are able to migrate inland as sea level rises by prohibiting new houses in areas likely to be eroded in the next thirty to sixty years and enacting other land use restrictions.[235]

The Endangered Species Act ("ESA")[236] may provide the foundation necessary to ensure these critical areas are protected. Congress enacted the ESA in 1970 to protect plants and animals at risk of becoming extinct by mandating conservation of these species and their habitats.[237] However, preserving habitat can also indirectly benefit coastal landowners. For example, the ESA restricted construction in the frontal dunes of the Alabama Coast in order to protect the habitat of the endangered Alabama Beach Mouse.[238] When Hurricane Ivan hit the Alabama coast in 2004, the buildings constructed within the frontal dunes were significantly more damaged than their counterparts behind the dunes.[239] The rebuilt frontal dunes provided significant protection again just a year later when Hurricane Katrina followed in 2005.[240]

In Florida, coastal development and rising seas threatens to squeeze out beaches that serve as sea turtle nesting areas. All three species that nest in Florida are endangered or threatened.[241] Protection of these beaches, which host 90 percent of all sea turtle nesting in the United States, is critical to their long-

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[230] *Id.* at 10.

[231] *See id.*

[232] CLIMATE CHANGE AND FLORIDA, *supra* note 29, at 4. Only Louisiana will suffer a greater loss than Florida of wetlands to open water. SOUTH FLORIDA, *supra* note 39, at 5.

[233] *Id.* at 4.

[234] *See* SCHOOL OF BIG STORMS, *supra* note 227, at 13.

[235] *Health and Effects*, *supra* note 43. For more information on the use of land use restrictions to prevent development and accommodate wetland migration, see *infra* Part IV.A.

[236] 16 U.S.C. §§ 1531-1544 (2006).

[237] *Id.* at § 1531.

[238] SCHOOL OF BIG STORMS, *supra* note 227, at 14.

[239] *Id.* at 15.

[240] *Id.*

[241] HAUSERMAN, *supra* note 24, at 18-19.

term survival, and therefore may be regulated under the ESA.[242] The ESA may provide the pressure necessary to develop new coastal management policies in Florida that will protect the sea turtles from extinction while simultaneously shielding coastal landowners from damages from sea level rise.

Unfortunately, steps to mitigate the damages of sea level rise may not be financially feasible or effective against the growing threat of Mother Nature.[243] This is especially true when considering the potentially damaging impacts of sea level rise combined with more intense storm activity. Although mitigation may be futile, it provides an immediate benefit by buying time to adapt, thus increasing the capacity of the population to deal with the effects of sea level rise in the form of storms, floods, and salt-water intrusion.[244]

D. Providing Financial Support

Smart adaptation requires more than good infrastructure and ecosystem management. As the Director of Wales' National Trust recognizes, insurance and compensation mechanisms are necessary to allow vulnerable communities and the environment to adapt to climate change both fairly and cost-effectively.[245] Insurance can mitigate the losses from the effects of sea level rise.

Because of the potentially widespread and catastrophic losses likely to occur, the government may recognize that some risks are too large and costly for the private insurance market to absorb on its own and choose to subsidize insurance. The Federal Emergency Management Agency estimates that a one-foot rise in sea level — a change Florida could see in the next 100 years[246] — would increase flood insurance premiums by thirty-five to sixty percent.[247] The Terrorism Re-Insurance Act of 2002 made $100 billion in federal money available as a backstop for buildings vulnerable to terrorism.[248] A similar fund has been advocated for cities threatened by climate change.[249] This is especially important in areas, such as Florida, where insurance companies have responded

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[242] *Id.* at 19.

[243] *See* SOUTH FLORIDA, *supra* note 39, at 9 ("Considering the resources it would require to elevate land, roads, houses, and local infrastructure, that is probably not a feasible alternative for the entire area [of South Florida]."); *see also* Steven Dube, *A Sea Change is Due, So How Can We Adapt to Floods and Erosion?*, WESTERN MAIL, Feb. 13, 2007, *available at* 2007 WLNR 2839034 (recognizing that a "'hold the line' approach with ever greater coastal defences is not affordable and in many cases counter-productive.").

[244] *See* Nicholls & Lowe, *supra* note 31, at 241.

[245] Dube, *supra* note 243.

[246] FEELING THE HEAT, *supra* note 84, at iv.

[247] VANISHING SHORES, *supra* note 49, at 2.

[248] Terrorism Risk Insurance Act of 2002, Pub. L. 107- 297, 116 Stat. 2322 (2002) (expired Dec. 30, 2005).

[249] Hertsgaard, *supra* note 82, at 102.

to the increased hurricane activity in recent years by raising rates significantly and even canceling policies outright.[250]

Although economic support may be necessary, subsidized insurance policies fail to sufficiently characterize the risk of coastal living and promote harmful development practices. Some criticize the National Flood Insurance Program as a federal subsidy on high-risk coastal development because billions of dollars are spent each year to build or rebuild in low-lying coastal areas, perpetuating the high-risk, low-utility practice of coastal development.[251] In practice, the program has not discouraged development, but only encouraged flood-resistant construction standards in order to minimize the damages in the event of a major flood.[252] Instead, access to low-cost flood insurance provides additional security to lenders and landowners wishing to build, and the possibility of limitless repeat claims without an increase in premiums allows people to keep rebuilding in areas prone to damage and devastation from sea level rise and storm activity.[253] If a publicly funded insurance program is to encourage adaptation to the effects of sea level rise, it must address the wasteful incentives promoted by current insurance schemes.

IV. ADAPTATION TO SEA LEVEL RISE

Adaptation is often criticized as an excuse for inaction.[254] However, adaptation measures are far less controversial than steps to curb GHG emissions and, therefore, are more likely to gain legislative support, become law, and stimulate change.[255] Despite this consensus and the relative cost-effectiveness of adaptation techniques, policy-makers and environmentalists tend to focus their attention on preventing global warming, rather than preparing for its effects.[256] Nonetheless, because some effects of sea level rise are inevitable, it is

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[250] *Id.*; UNFAVORABLE TIDE, *supra* note 65, at 44.

[251] *See, e.g.*, Randall, *supra* note 60, at 151-58.

[252] *But cf.* Titus, *Restructure*, *supra* note 78, at 769 (noting that in some cases, such as when houses are built on pilings, wetland migration is encouraged because property can be gradually converted to marshland without threatening the structures themselves).

[253] *See* Lisa A. St. Amand, *Sea Level Rise and Coastal Wetlands: Opportunities for a Peaceful Migration*, 19 B.C. ENVTL. AFF. L. REV. 1, 21 (1991).

[254] Hertsgaard, *supra* note 82, at 102; *see also* AL GORE, EARTH IN THE BALANCE: ECOLOGY AND THE HUMAN SPIRIT (1993) ("Modest shifts in policy, marginal adjustments in ongoing programs, moderate improvements in laws and regulations, rhetoric offered in lieu of genuine change — these are all forms of appeasement, designed to satisfy the public's desire to believe that sacrifice, struggle, and a wrenching transformation of society will not be necessary."); Rick Salutin, *Adaptation Equals Doing Nothing*, GLOBE & MAIL, Feb. 9, 2007 ("[Adaptation] is far too impressive a word for doing nothing . . . . What's the alternative: sitting there as the tide comes in and covers you? Is this a policy?"), *available at* 2007 WLNR 2526311.

[255] Titus, *Restructure*, *supra* note 78, at 722.

[256] *Id.* at 721; *see id.* at 773 ("It makes no sense to spend tens of billions of dollars to slow global warming and do nothing to adapt to its consequences. It is time to direct the federal bureaucracy to

essential that Florida attempt to adapt to the changing environment to protect coastal residents and ecosystems.[257] An effective response to sea level rise requires a combination of prevention of the full effects of climate change, mitigation of the inevitable effects, and adaptation to the conditions that cannot be avoided.

Adaptation involves changing human interaction with the environment to promote less damaging effects.[258] An array of potential adaptive responses exists, including adapting technology, behavior, management techniques, and policy.[259] For Florida, adaptation entails adopting sound coastal zone management policies and, in some cases, complete retreat from vulnerable coastlines.

A. Land Management

There is a double disadvantage to excessive and rapid coastal settlement.[260] First, uncontrolled coastal development damages sensitive and important ecosystems.[261] Second, coastal settlement is likely to expose residents to seaward hazards such as sea-level rise and tropical storms, both of which are likely to become more serious as the planet warms.[262] Unfortunately, these considerations do not have the influence on settlement patterns that they deserve.[263] Effective adaptation through land management will require a combination of effective and enforceable regulations and economic incentives to redirect settlement to better-protected locations and promote investments in appropriate infrastructure at inland locations.[264]

The Coastal Zone Management Act ("CZMA") encourages states to enact policies that protect the economic, cultural, and ecological value of coastal areas and minimize vulnerability to floods and erosion hazards by providing financial assistance and incentive programs for policies conforming to CZMA standards.[265] Congress enacted the CZMA in response to reports that state and local land and water planning in coastal areas were inadequate to protect their

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start preparing for the consequences of global warming.").

[257] IPCC FAR WGII, *supra* note 52, at 19 ("There are some impacts for which adaptation is the only available and appropriate response."); *see also* McGranahan, Balk & Anderson, *supra* note 62, at 17 (noting that "it is too late to rely solely on mitigation").

[258] Hertsgaard, *Front Lines*, *supra* note 82, at 102.

[259] IPCC FAR WGII, *supra* note 52, at 17. The cost of adaptation techniques is uncertain, given that they are highly dependent on the risk, geography, and political situation of a particular location. *Id.*

[260] McGranahan, Balk & Anderson, *supra* note 62, at 33.

[261] *Id.*; *see also supra* notes 50-59 and accompanying text.

[262] McGranahan, Balk & Anderson, *supra* note 62, at 33.

[263] *Id.*

[264] *Id.*

[265] 16 U.S.C. §§ 1452(2), 1455 (2006).

natural, commercial, recreational, ecological, industrial, and aesthetic value.[266] The success of the program in protecting wetlands in the past is a "powerful testament" to the influence prior planning can have on improving a situation.[267] A more recent bill, the Disaster Mitigation Act ("DMA"), uses similar incentives to encourage states to enact disaster response, recovery, and mitigation efforts.[268] Both the CZMA and the DMA are potent tools for Florida to address the problems associated with sea level rise through advanced planning and land regulations.[269]

For example, the town of Nagshead, North Carolina is located in a hurricane-prone area, and, under the auspices of the CZMA, has adopted a building moratorium following disaster events.[270] During the thirty-day period following a disaster, officials may adjust zoning standards and adopt new adopt new disaster mitigation standards in response to any newly created inlets or eroded areas.[271] Subsequent construction is required to comply with the new codes and standards.[272] This policy provides the flexibility needed to redesign standards to circumstances following a storm.[273]

Similarly, Maine has a comprehensive shoreline management scheme that takes into account sea level rise, the potential damage to people and property, and the need for wetland preservation. The Coastal Sand Dunes Law permits construction on dunes only if it can be shown that the proposed development will not cause unreasonable erosion, significantly harm any wildlife habitat or travel corridor, or unreasonably interfere with the natural flow of water and movement of sand.[274] These regulations require sea level rise be taken into account when determining size, density, and location restrictions for proposed development. Development is prohibited on the frontal dunes and in any area where structures are likely to be damaged as a result of changing shorelines in the next hundred years.[275] In addition, a permit must be obtained to rebuild structures severely damaged by storms,[276] and structures must be relocated when coastal wetlands extend to any portion of it for at least six months.[277] Through

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[266] *Id.* §§ 1451(b), (h).

[267] Titus, *Restructure*, *supra* note 78, at 769.

[268] 42 U.S.C. § 5165 (2006).

[269] *See generally* John R. Nolon, *Disaster Mitigation Through Land Use Strategies*, 23 PACE ENVTL. L. REV. 959 (2006) (advocating use of proper land use decision-making by local governments to create disaster resilient communities).

[270] *Id.* at 974.

[271] *Id.*

[272] *Id.* at 975.

[273] *Id.*

[274] ME. REV. STAT. ANN. tit. 38, § 480-D (2007).

[275] 355 ME. CODE R. § 5(C) (Weil 2007).

[276] *Id.* at § 6(E).

[277] *Id.* at § 10(A).

extensive educational outreach, this scheme puts coastal landowners on notice that relocation of their structures may be necessary.[278]

Although not threatened by sea level rise, the city of Boulder, Colorado has adopted a hazard mitigation plan under the DMA that could easily be adapted for coastal areas. Under this plan, flood damage is mitigated by requiring the city to prevent redevelopment of property significantly damaged by flood and to prepare a plan for property acquisition of flood-damaged and undeveloped land in high-hazard flood areas.[279] Undeveloped high-hazard flood areas are to be retained in their natural state when possible while encouraging compatible uses of wildlife habitat, wetlands, and trails.[280]

Placing the risks of coastal living on private landowners can also encourage sustainable coastal development.[281] Currently, few of the environmental disadvantages of coastal urbanization are reflected in economic incentives that drive urban development.[282] For the most part, government flood management policies have subsidized the costs of living in dangerous floodplains by providing hundreds of millions of dollars each year to repair recurring and foreseeable damage to unwise and unsustainable development in both the public and private sectors.[283] As a result, coastal property values are artificially inflated and do not properly reflect the economic and environmental risk of inhabiting these areas; as a result, property owners are left with a distorted perception of flood risk.[284]

The federal government has already exempted undeveloped barrier islands from federal subsidies for highways and flood insurance, effectively making development extremely unattractive and prohibitively expensive in those areas.[285] Expenditures on flood insurance, flood control barriers, and disaster relief should be similarly minimized to discourage settlement on floodplains that are both dangerous and ecologically sensitive.[286]

The Harris County Flood Control District ("HCFC") in Houston, Texas,

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[278] *See* Amand, *supra* note 253, at 8, 18 (acknowledging that "public understanding and acceptance is vital to the success of any program that aims to have property owners abandon their shoreline residences as the sea encroaches"). Similar schemes have also been successfully implemented in New Hampshire, New York, and the Carolinas. *See* N.H. REV. STAT. ANN. § 483-B:1 to :20 (2007); N.Y. ENVTL. CONSERV. LAW §§ 34-0104 to -0109 (McKinney 2007); N.C. GEN. STAT. §§ 113A-110 to -129 (2007); S.C. CODE ANN. §§ 48-39-290 to -300 (2007).

[279] BOULDER VALLEY COMPREHENSIVE PLAN 32-33 (City of Boulder and Boulder County eds., 2005), *available at* http://www.bouldercolorado.gov/files/PDS/BVCP/bvcp.pdf.

[280] *Id.*

[281] HAUSERMAN, *supra* note 24, at 6.

[282] McGranahan, Balk & Anderson, *supra* note 62, at 20.

[283] Daniel D. Barnhizer, *Givings Recapture: Funding Public Acquisition of Private Property Interests on the Coasts*, 27 HARV. ENVTL. L. REV. 295, 296 (2003).

[284] *Id.* at 296-97.

[285] 16 U.S.C. § 3501(b) (2006).

[286] HAUSERMAN, *supra* note 24, at 6-7.

implemented a comprehensive flood control plan after Tropical Storm Alison dropped thirty-seven inches of rain on the city in September 2005, causing $5 billion in flood damages.[287] After obtaining an updated flood map, the HCFC has also initiated a major campaign to convince homeowners to buy flood insurance even when not located in the 100-year flood plain, and will buy back property in high-risk areas at full market value.[288] In an attempt to "work with nature instead of against it," the HCFC is designing new retention areas and channels that follow natural routes in what they call "the new bayou."[289] The new design drains the city more effectively, uses less concrete, and adds more green space to the city.[290]

Along with higher insurance rates, more stringent building codes discourage building by increasing the cost of living on the coast.[291] Density restrictions further limit development.[292] To be effective, exemptions should be granted sparingly. In 2001, Florida adopted new hurricane building codes, but approved extensive exemptions to residents and businesses in the Panhandle on the basis that the area was less hurricane-prone than the rest of the state and that the low-income population of the area would be unable to rebuild or afford new homes.[293] Because the houses in this area were not required to rebuild stronger and safer, Hurricanes Ivan and Dennis devastated the area in 2004 and 2005 respectively.[294] Improved building codes help the economy by reducing risk and provide safer shelter for coastal residents.[295]

These moves require political will, as well as financial and human capital and time.[296] In addition, a long lead-time should be built into measures to avoid severe disruptions, although, for some places, it may already be too late.[297] Regrettably, even prior coastal planning was not sufficient to save New Orleans or the Chesapeake Bay in Maryland and Virginia.[298] Therefore, in some instances, complete abandonment of risky property may be the best option.

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287 SCHOOL OF BIG STORMS, *supra* note 227, at 8-9.

288 *Id.*

289 *Id.*

290 *Id.*

291 SOUTH FLORIDA, *supra* note 39, at 11.

292 Titus, *Rising Seas*, *supra* note 80, at 1318.

293 SCHOOL OF BIG STORMS, *supra* note 227, at 16.

294 *Id.* at 17.

295 SCHOOL OF BIG STORMS, *supra* note 227, at 17.

296 McGranahan, Balk & Anderson, *supra* note 62, at 33.

297 *Id.* at 35.

298 *See generally* Erin Ryan, *New Orleans, the Chesapeake, and the Future of Environmental Assessment: Overcoming the Natural Resources Law of Unintended Consequences*, 40 U. RICH. L. REV. 981 (2006) (describing how attempting to channel Mississippi River to avoid flooding destroyed wetlands that could have slowed Hurricane Katrina's storm surge and how placing development boundary in coastal areas doomed wetlands to failure by preventing them from migrating inland as sea levels rise).

B. Retreat

Retreat may be the most effective and economically efficient method of limiting the risks of sea level rise and climate change to people and the environment.[299] "Sometimes the best insurance against flood damage is simply getting out of Nature's way,"[300] and the risks to human settlements can be significantly reduced if they are relocated away from the coast.[301] Moreover, allowing the sea to advance permits the people to continue to enjoy intertidal public land for recreational activities. Retreat also reduces the pressures human settlements place on coastal ecosystems that provide a buffer to storm activity.[302]

Unfortunately, current population movement is in the opposite direction,[303] with growth rates in coastal counties in Florida approaching twenty percent.[304] Over half of the United States population lives in coastal counties that comprise only seventeen percent of the land area.[305] Nonetheless, these approaches should be considered now, when they are relatively cost-effective.[306] These opportunities will be prohibitively costly if left until housing developments completely cover shorefront property.

To facilitate a policy of retreat, the government may buy coastal property or prevent development of private land outright.[307] Governments can discourage development by increasing the cost to the landowner[308] or limit development through the use of use restrictions, setback lines, and rolling easements.

One option for obtaining property threatened by sea level rise is through reservations of use and occupancy. The government may obtain risky property

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[299] Randall, *supra* note 60, at 168-69. Note that problems exist in the United States, where land acquisition must be accomplished using eminent domain. *Id.*

[300] SCHOOL OF BIG STORMS, *supra* note 227, at 9 (quoting Jim Blackburn of the Galveston Bay Conservation and Protection Association).

[301] McGranahan, Balk & Anderson, *supra* note 62, at 20.

[302] *Id.*

[303] *Id.*; *see also* Nicholls & Lowe, *supra* note 31, at 229 (noting that coastal populations are growing more rapidly than the global mean as a result of coastward migration and urbanizing of these areas); Randall, *supra* note 60, at 145 (reporting that the coastal population increases by 3,600 people per day despite the long-term costs of doing so).

[304] HAUSERMAN, *supra* note 24, at 3.

[305] Barnhizer, *supra* note 283, at 295; *see also* HAUSERMAN, *supra* note 24, at 3 ("Eighty percent of Floridians live or work in one of the state's 35 coastal counties.").

[306] Titus, *Transportation*, *supra* note 66, at 10 (noting the high cost of retreat, especially in areas already densely-developed); *see also* McGranahan, Balk & Anderson, *supra* note 62, at 20.

[307] Randall, *supra* note 60, at 168; Titus, *Restructure*, *supra* note 78, at 734. In all cases, governments tend to use land-planning measures, rather than technology, to facilitate retreat. Titus, *Restructure*, *supra* note 78, at 734. Whether these actions would constitute a taking under the Constitution requiring just compensation is beyond the scope of this article, but has been discussed extensively elsewhere. *See, e.g.*, Titus, *Rising Seas*, *supra* note 80, at 1334-61.

[308] See *supra* Part IV.A for a discussion on discouraging development through regulation and incentives.

through purchase or condemnation, but allow the previous owners to continue to occupy the land for their life or a term of years.[309] This method eases the transition from private to public property, and allows the government to acquire property at a lower cost.[310] The National Park Service currently employs these types of reservations when it creates new parks and has encountered few problems.[311] The use of reservations could be a cost-effective method to acquire both ecologically sensitive property to enable wetland migration and property vulnerable to sea level rise to prevent loss of life and land.[312]

Abandonment can be encouraged through relocation subsidies. When the waters of the Great Lakes began to rise rapidly in the mid-1980s, Michigan officials implemented a program to facilitate orderly retreat from eroding shorelines.[313] The program provided subsidies in the form of lower interest loans or one-time payments used to assist in relocation of houses, septic systems, water lines, and electric cables threatened by erosion.[314] Additionally, funds could be used to demolish and remove structures that could not be moved.[315] The success of such subsidies requires convincing homeowners of the imminence of sea level rise, as well as providing an amount sufficient to make relocation an attractive option.

"Setbacks" prohibit development seaward of the setback line, which is commonly based on erosion rates, elevation, and estimated changes in the shoreline.[316] Setbacks may also decrease the value of threatened land to the point where it is no longer economically feasible to develop the property or build a barricade.[317] Unfortunately, drawing an appropriate setback line is nearly impossible given the uncertainty of shoreline changes.[318] In addition, setback lines may provide only a temporary solution, as eventually the shore would retreat to any line that is established.[319]

Preventing development outright carries the highest social cost because the property cannot be used in the time between the present and eventual loss to the sea.[320] In some cases, the benefits of building a rental unit directly on the water,

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[309] Amand, *supra* note 253, at 19. Generally, holders of these reservations must obtain permission before making improvements to prevent further development. *Id.*

[310] *Id.*

[311] *Id.*

[312] *Id.* at 19-20.

[313] *Id.* at 27.

[314] *Id.*

[315] *Id.*

[316] Titus, *Restructure*, *supra* note 78, at 736.

[317] Titus, *Rising Seas*, *supra* note 80, at 1312.

[318] *Id.* at 1285.

[319] *Id.*

[320] *Id.* at 1322.

even if it only survives a short period, may outweigh the costs of doing so.[321] As a result, some states, including Maine, Rhode Island, South Carolina, and Texas, regulate land use through "rolling easements."[322] Under this scheme, the government purchases an easement that allows property owners to build, but only on the condition that they will remove the structure if and when it is threatened by an advancing shoreline.[323] Landowners may build at their own risk, but cannot restrict the natural advance of the sea and deny the public the opportunity to walk along and enjoy the beach.[324] Building codes can be changed that require buildings to be moveable in case they are threatened by encroaching seas.[325]

Another type of rolling easement allows the government to step in and take possession of private property whenever the sea level rises a certain amount or the public wetlands or dunes migrate inland enough that a structure sits on public property.[326] The knowledge that lands might eventually become inundated with rising seas, or transferred to the government, prevents landowners from investing in inappropriate construction, expansions, or upgrades on their property.[327] Instead, an owner is likely to build moveable structures, and will forego constructing bulkheads that cannot completely pay for themselves before they must be removed.[328] Rolling easements carry the least social cost and put landowners on notice that one day, perhaps a century in the future, the property must be abandoned and the structures removed.[329]

Some countries have forced abandonment in high-risk areas. The Netherlands, in anticipation of increased river flows resulting from melting ice, is no longer attempting to contain floods.[330] Instead, it will accommodate the extra water by allowing pre-designated areas to flood.[331] As part of this plan, a sparsely populated strip of land will be allowed to flood to spare the more heavily populated areas downstream.[332] Although forced abandonment is an extreme measure, the alternative may be losing coastal cities altogether.[333]

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321 *Id.*

322 HEALTH AND EFFECTS, *supra* note 43.

323 *Id.*

324 SOUTH FLORIDA, *supra* note 39, at 9.

325 Titus, *Restructure*, *supra* note 78, at 736.

326 *Id.* at 738-39.

327 *Id.* at 738.

328 Titus, *Rising Seas*, *supra* note 80, at 1326.

329 *Id.* at 1329.

330 Hertsgaard, *supra* note 82, at 102.

331 *Id.*

332 *Id.*

333 *Id.* The Welsh have similarly pledged to work with the forces of nature whenever possible. *See generally* Dube, *supra* note 243.

CONCLUSION

Sea level rise is a growing threat to coastal areas, their unique ecosystems, and the people and wildlife that inhabit them. The state of Florida is especially vulnerable given its unique proximity to water, even topography, economic dependence on tourism and agriculture, and exposure to tropical storm activity. As a result, it is imperative that the state takes action to respond to sea level rise through prevention, mitigation, and adaptation. Reducing atmospheric concentrations of GHGs will prevent sea level rise from reaching catastrophic proportions. Many successful programs have been implemented across the nation to research and encourage the development and use of alternative fuels, promote energy efficiency, and store carbon in oceanic and terrestrial sinks. The inevitable effects of sea level rise can be mitigated through proper planning and controlling coastal development. Coastal defense structures, such as dikes and bulkheads, and financial support can minimize the risk and damages to human life and property. Finally, Florida should concede defeat in the most risk-prone areas and encourage retreat through regulation and incentives. Only through a combination of these three methods can the state successfully confront the daunting challenge that sea level rise poses to its coastal lands, ecosystems, and residents.

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