FLORIDA AND CLIMATE CHANGE

THE COSTS OF INACTION

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EXECUTIVE SUMMARY

In July 2007, Governor Charlie Crist established greenhouse gas emission targets for the state of Florida, including an 80 percent reduction below 1990 levels by 2050. Although achieving this target will involve nontrivial expenditures, the *failure* to avert severe climate change would have even more severe consequences for Florida, in cold hard cash as well as human and ecological impacts.

Arguments against strong action to combat climate change often implicitly assume that inaction would be cost-free — that we can chose a future without significant impacts from climate change even if emissions of carbon dioxide and other greenhouse gases continue to grow unchecked. But the overwhelming scientific consensus now holds that this rosy assumption is simply wrong, and that the more greenhouse gases are released, the worse the consequences will be.

The stakes are high, the risks of disastrous climate impacts are all too real, and waiting for more information is likely to mean waiting until it is too late to protect ourselves and our descendants. If a bad outcome is a real risk — and run-away greenhouse gas emissions lead to a very bad outcome indeed — isn't it worth buying insurance against it? We buy fire insurance for our homes, even though any one family is statistically unlikely to have a fire next year. Young adults often buy life insurance, out of concern for their families, even though they are very unlikely to die next year. Taking action to reduce greenhouse gas emissions and control climate change is life insurance for the planet, and for the species that happen to live here, *Homo sapiens* included.

This report examines the potential costs to Florida if greenhouse gas emissions continue unchecked. To do so, we compare an optimistic scenario and a pessimistic one. Under the optimistic scenario — called "rapid stabilization" — the world begins taking action in the very near future and greatly reduces emissions by mid-century with additional decreases through the end of the century. Under the pessimistic scenario — called "business-as-usual" — greenhouse gas emissions continue to skyrocket throughout the 21st century. The business-as-usual scenario is

based largely on the 2007 report of the Intergovernmental Panel on Climate Change (IPCC), a panel of more than 2,000 scientists whose consensus findings are approved by all participating governments, including the United States.

The cost of inaction — the difference between these two scenarios — is the human, economic, and environmental damage that may be avoidable with vigorous, timely actions to reduce greenhouse gas emissions. Many of these costs do not have dollar-and-cents price tags; increased deaths due to more intense hurricanes,[1] or the destruction of irreplaceable ecosystems by sea-level rise or temperature increases, transcend monetary calculation. Lives, and ways of life, are at stake; the most important damages are priceless.

Other costs, which do have explicit price tags, will be enormous. Among the many climate damages discussed in this report, we have estimated monetary values for four major categories:

- loss of tourism revenue, if the more unpleasant climate of the business-as-usual case makes Florida no more attractive year-round than it is today in its slowest season (autumn);
- increased hurricane damages, due to the greater frequency of Category 4 and 5 storms predicted by many climate scientists;
- the value of residential real estate that is at risk from sea-level rise; and
- increased costs of electricity generation as temperatures and air-conditioning requirements rise.

For just these four categories — loss of tourism revenue, increased hurricane damages, at-risk residential real estate, and increased electricity costs — the annual costs of inaction are projected to total $92 billion by 2050 and $345 billion by 2100, figures that respectively would constitute 2.8 percent and 5.0 percent of the state's projected Gross State Product (see table ES-1). If estimates were included for other sectors such as agriculture, fisheries, insurances, transportation, and water systems — to say nothing of ecosystem damages — the totals would be even larger.

Table ES-1. The Costs of Inaction

in billions of 2006 dollars, except percentages

	2025	2050	2075	2100
Tourism	$9	$40	$88	$167
Hurricanes	$6	$25	$54	$104
Electricity	$1	$5	$10	$18
Real Estate	$11	$23	$33	$56
Summary: Costs of Inaction				
in billions of 2006 dollars	$27	$92	$184	$345
as % of projected Florida GSP	1.6%	2.8%	3.9%	5.0%

FLORIDA'S FUTURE CLIMATE

Florida's future climate depends on overall emissions of greenhouse gases today and in the decades to come, and — because carbon dioxide persists in the atmosphere for a century or more — on the impacts of accumulated past emissions. We compare two scenarios: an optimistic *rapid stabilization case* and a pessimistic *business-as-usual case*. Neither, of course, is absolutely certain to occur; predicting long-term climate outcomes is difficult, especially for an area as small as a single state. But an enormous amount is now known about the likely effects of climate change; it is far too late to wait for more information before taking action. Based on the current state of knowl-

edge, our scenarios represent plausible extremes: what is expected to happen if the world succeeds in a robust program of climate mitigation, versus what is expected to happen if we do very little. The difference between the two is the avoidable damage to Florida. It can be seen as the benefits of mitigation, or, from an opposite perspective, the costs of inaction.

Figure ES-1. Two Future Climate Scenarios for Florida

Rapid Stabilization Case

Lowest emissions under discussion today

- ✓ 50% reduction in current global emissions by 2050
- ✓ 80% reduction in current U.S. emissions by 2050

Plus, good luck in the outcomes of uncertain climate impacts

- ✓ Precipitation remains constant
- ✓ Hurricane intensity remains constant

Business-as-Usual Case

Steadily increasing emissions throughout this century

- ✓ Modeled on the high-end of the likely range of the IPCC's A2 scenario

Plus, bad luck in the outcomes of uncertain climate impacts

- ✓ Precipitation patterns changes (less rain in Florida)
- ✓ Hurricane intensity increases

Table ES-2. Two Future Climate Scenarios for Florida

	2025	2050	2075	2100
Annual Average Temperature *(in degrees Fahrenheit above year 2000 temperature)*				
Rapid Stabilization Case	0.6	1.1	1.7	2.2
Business-as-Usual Case	2.4	4.9	7.3	9.7
Sea-Level Rise *(in inches above year 2000 elevation)*				
Rapid Stabilization Case	1.8	3.5	5.3	7.1
Business-as-Usual Case	11.3	22.6	34.0	45.3

RAPID STABILIZATION CASE

With immediate, large-scale reductions in greenhouse gas emissions, and some good luck in the outcome of uncertain climate impacts, it is still possible for changes in the world's climate to remain relatively small. To keep the global average temperature from exceeding 2°F above year 2000 levels — an important threshold to avoid melting of the Greenland ice sheet and other dangerous climate impacts — we must stabilize the atmospheric concentration of carbon dioxide at 450 parts per million (ppm) or lower. In order to stabilize at 450 ppm, global emissions must reach one-half their current levels by 2050 and one-quarter of current levels by 2100. Because the United States' one-twentieth of world population bears responsibility for a full one-fifth of these emissions, U.S. emissions would have to decline 80 percent by 2050 in order to meet these goals.

In the rapid stabilization case, climate change has only moderate effects. Florida's annual average temperature increases 1°F by 2050 and 2°F by 2100, while sea levels rise by 3.5 inches by 2050 and 7 inches by 2100.

The rapid stabilization case also assumes the best results of the uncertain impacts of extreme weather: precipitation levels remain at historical levels, and extreme heat waves continue to be rare, brief events with manageable impacts in Florida. The frequency and intensity of hurricanes also remain at their historical levels, implying that in the course of an average 100 years Florid-

ians can expect 73 hurricanes, of which 24 will be Category 3 or higher, and one year with four or more hurricanes.

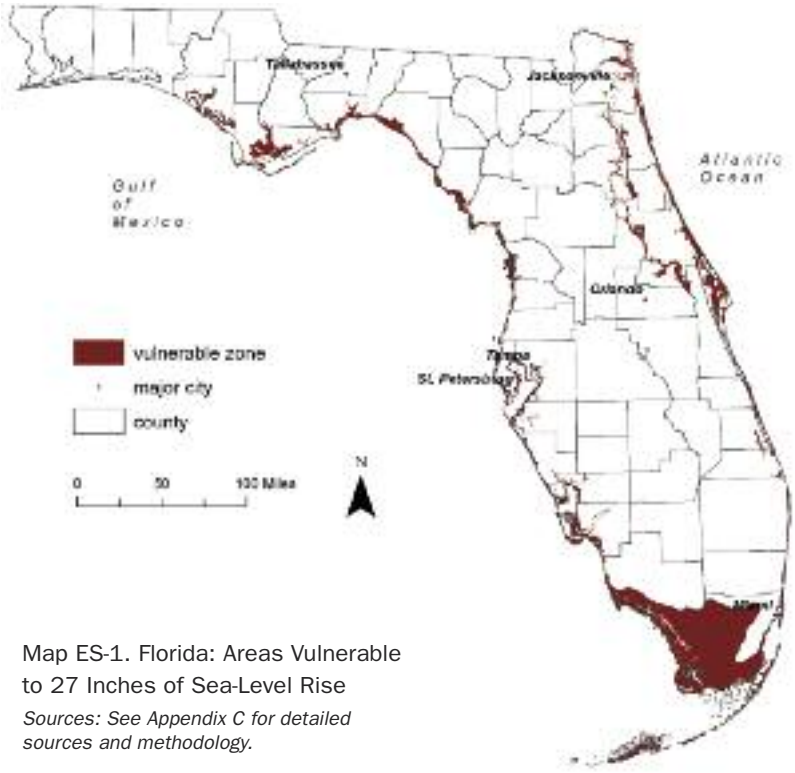
The rapid stabilization case is not a panacea. The state will still have to cope with its existing social and environmental problems, including water shortages, growing demands for electricity, the effects of hurricanes, the costs and constraints of Everglades restoration, and the impacts of ever-growing numbers of residents and visitors crowding into an already well-populated region. But at least climate change will not make these problems much worse — if we implement the rapid stabilization case by significantly reducing greenhouse gas emissions, starting soon and continuing throughout the century. Although Florida cannot itself ensure this outcome, its leadership can provide momentum toward the concerted actions that must be taken in the state, in the nation, and around the world.

BUSINESS-AS-USUAL CASE

And what if the world fails to achieve the needed reductions in emissions? The business-as-usual case assumes steadily increasing emissions, along with bad luck with the uncertain impacts of extreme weather. Specifically, it rests on the worst of what the IPCC calls its "likely" predictions for the A2 scenario, in which atmospheric concentrations of carbon dioxide exceed the critical 450 ppm threshold by 2030 and reach 850 ppm by 2100.

In the business-as-usual case, Florida's average annual temperatures will be 5°F higher than today in 2050 and 10°F higher in 2100. Sea-level rise will reach 23 inches by 2050, and 45 inches by 2100. The estimates for sea-level rise under the business-as-usual case diverge somewhat from the A2 scenario as presented in the most recent IPCC report, which — controversially — excludes some of the feedback mechanisms that could accelerate the melting of the Greenland and Antarctic ice sheets. This area of climate science has been developing rapidly, and the business-as-usual case estimates are based the most recent work of Stephan Rahmstorf, which appeared too late for inclusion in the IPCC report.

U.S. Geological Survey (USGS) maps and Geographic Information System (GIS) technology make it possible to show an approximation of Florida's coastline at 27 inches of sea-level rise, which is projected to be reached by around 2060 in the business-as-usual case. For simplicity, we refer to land area that would be inundated in Florida with 27 inches of sea-level rise as the year 2060 "vulnerable zone." Map ES-1, left, shows the entire state of Florida with the vulnerable zone in red. (More detailed maps are available in the main body of the report.)



Map ES-1. Florida: Areas Vulnerable to 27 Inches of Sea-Level Rise

Sources: See Appendix C for detailed sources and methodology.

The vulnerable zone includes nine percent of Florida's current land area, or some 4,700 square miles. Absent successful steps to build up or otherwise protect them — which will be expensive and in some areas is likely impossible — these lands will be submerged at high tide. The vulnerable zone includes 99.6 percent, all but six square miles, of Monroe County (Florida's southwest tip and the Keys). It also includes 70 percent of Miami-Dade County, and 10 to 22 percent of 14 other counties. Almost one-tenth of Florida's current population, or 1.5 million people, live in this vulnerable zone; one-quarter of the affected population lives in Miami-Dade County.

The vulnerable zone also includes residential real estate now valued at over $130 billion, half of Florida's existing beaches, and 99 percent of its mangroves, as well as the following significant structures (among many others):

- 2 nuclear reactors;
- 3 prisons;
- 37 nursing homes;
- 68 hospitals;
- 74 airports;
- 82 low-income housing complexes;
- 115 solid waste disposal sites;
- 140 water treatment facilities;
- 171 assisted livings facilities;
- 247 gas stations
- 277 shopping centers;
- 334 public schools;
- 341 hazardous-material cleanup sites, including 5 Superfund sites;
- 1,025 churches, synagogues, and mosques;
- 1,362 hotels, motels, and inns; and
- 19,684 historic structures.

While efforts to protect at least some portions of the vulnerable zone will surely be taken, they may prove unavailing in some locales (and will be costly even where effective). As the Science and Technology Committee of the Miami-Dade County Climate Change Task Force recently noted, "the highly porous limestone and sand substrate of Miami-Dade County (which at present permits excellent drainage) will limit the effectiveness of widespread use of levees and dikes to wall off the encroaching sea."

Transportation infrastructure in Florida will be damaged by the effects of sea-level rise, particularly in combination with storm surges. Docks and jetties, for example, must be built at optimal heights relative to existing water levels, and rapid sea-level rise would force more frequent rebuilding. Roads, railroads, and airport runways in low-lying coastal areas all become more vulnerable to flooding as water levels rise, storm surges reach farther inward, and coastal erosion accelerates. Even roads further inland may be threatened, since road drainage systems become less effective as sea levels rise. Many roads are built lower than surrounding land to begin with, so reduced drainage capacity will increase their susceptibility to flooding during rainstorms.

Other important climate and environmental changes in the business-as-usual case include:

- **Hurricane intensity will increase**, with more Category 4 and 5 hurricanes occurring as sea-surface temperatures rise. Greater damages from more intense storms come on top of the more severe storm surges that will result from higher sea levels.
- **Rainfall will become more variable**, with longer dry spells, and will decrease by 10 percent overall, contributing to drought conditions.
- **Heat waves will become more severe and more common**, with new record temperatures and a gradual decline in nighttime cooling. The average "heat index" (temperature combined with humidity) in summer will 15–20 percent higher in much of the state. Miami will become several degrees hotter than today's Bangkok (probably the world's hottest, most humid major city at present), and daily highs in many Florida cities will exceed 90 degrees nearly two-thirds of the year.
- **Ocean temperature and acidity levels will increase**, causing coral bleaching and disease, with harmful effects on the many marine species that depend on coral ecosystems.

These effects will have significant impacts on Florida's industries and infrastructure.

Tourism, one of Florida's largest economic sectors, will be the hardest hit as much of the state's wealth of natural beauty — sandy beaches, the Everglades, the Keys — disappears under the waves. As noted in Table ES-1, costs of inaction are projected to total $9 billion by 2025, $40 billion by mid-century, and $167 at the end of the century.

Agriculture, forestry and fisheries will also suffer large losses. Well-known and economically important Florida products like orange juice and pink shrimp may become a thing of the past. And even as higher temperatures and more-irregular rainfall increase the demand for crop and livestock irrigation, freshwater supplies will become scarcer as saltwater intrusions contaminate them.

The **insurance industry** also will be affected by climate change, as it seeks to adjust to a new, riskier Florida. Florida's residents and businesses will continue to struggle to find affordable insurance coverage.

High temperatures will increase demands for **electricity**, primarily to supply air conditioning. The extra power plants and the electricity they generate are not cheap; the annual costs of inaction are $5 billion in 2050 and $18 billion in 2100, as reported in Table ES-1 above.

The same temperature increases will also degrade the performance of power stations and transmission lines, making them operate less efficiently; partly as a result, every additional degree Fahrenheit of warming will cost consumers an extra $3 billion per year by 2100.

Increased demand for electricity also has severe implications for water resources, as all coal, oil, gas, and nuclear power plants must be cooled by water.

The business-as-usual case will only intensify Florida's looming **water** crisis in other ways as well. Under hotter and drier conditions, agricultural and domestic users will need more water; the survival of irrigated winter agriculture in the state will be threatened. The one potentially vast source of fresh water, desalination of ocean water, is an expensive and technically complex process. The first large-scale facility to attempt ocean water desalination in the state, at Tampa Bay, has been plagued by technical delays and cost overruns. If enough desalination plants could be made available, the additional water needs under the business-as-usual case would add several billion dollars a year to the costs of inaction.

In both climate scenarios for Florida, climate change is likely to have important effects on the economic damages and deaths that result from **hurricanes**; in the business-as-usual case, these damages and deaths will be on a much larger scale. The cost of inaction attributable to greater hurricane damages, $25 billion by 2050 and $104 billion by 2100, as reported in Table ES-1, includes the effects of coastal development and higher population levels, sea-level rise as it impacts on storm surges, and greater storm intensity. In addition, the cost of inaction in the business-as-usual case includes an average of 19 additional deaths from hurricanes per year in 2050 and 37 additional deaths in 2100; these numbers are in addition to the deaths expected under the rapid stabilization case.

Finally, the business-as-usual case has important, and in some cases irreversible, impacts on priceless natural **ecosystems**. Hotter average temperatures, rising sea levels, changes in precipitation, increased storm damages, and increased ocean acidity and temperatures will all cause visible harm to well-known parks and other natural areas. Wholesale extinctions and ecosystem destruction are unavoidable in the business-as-usual future, and the strategy that could save the most species and ecosystems — allowing wetlands to migrate, taking over what are now dry lands — is extremely unlikely to occur, at least on a wide scale. Natural ecosystems in every corner of Florida will be affected.

And nowhere will the impacts be more devastating than in the **Everglades**. Rising sea levels under the business-as-usual case cause water to encroach 12 to 24 miles into the broad low-lying area of the Everglades, leaving the lower Everglades completely inundated. As large parts of the Everglades wetlands are converted into open water, nurseries and shelter for many fish and wildlife species will be lost. The 10°F increase in air temperature expected by 2100 will draw species northward out of the Everglades, but if current drylands are protected with seawalls this migration will be thwarted, and species will disappear from Florida, or in some cases become extinct.

These impacts on industry, infrastructure, and ecosystems — the cost of inaction — vastly outweigh expenditures on renewable energy, energy-efficient transportation and appliances, and other measures that are required to reduce emissions. If Florida makes the necessary efforts to achieve its ambitious target of 80 percent reduction in emissions by 2050, and the rest of the world follows suit with significant and immediate action, we can achieve the "rapid stabilization future." If, on the other hand, decisive climate action fails, we may well find ourselves living in the "business-as-usual future."

To reject a potential 10°F increase in temperature and 3 feet or more in sea-level rise this century, Floridians — and residents of other U.S. states and of other nations — must commit to beginning in the very near future to take steps to substantially reduce global greenhouse gas emissions. The only other available option is to place a very risky bet — that somehow, despite the most current scientific knowledge, business-as-usual emissions will not trigger a climate catastrophe. If we gamble and lose, we and our children cannot walk away from the consequences.