SPECIAL ADVERTISING REPORT

# Explore

SUMMER 2016

Research at the University of Florida


## Climate Change

UF Researchers Rise
To The Challenge

UF | UNIVERSITY of FLORIDA

SPECIAL ADVERTISING REPORT

# Explore

Summer 2016, Vol. 21, No. 2

Research at the University of Florida



*About the cover:*
*Laser scans of buildings are combined with data from UF's GeoPlan Center to simulate the effects of rising seas on Cedar Key, Fla.*

UF




*Explore* is published by the UF Office of Research. Opinions expressed do not reflect the official views of the university. Use of trade names implies no endorsement by the University of Florida.

**explore.research.ufl.edu**

**Editor:**
Joseph M. Kays
joekays@ufl.edu

**Art Director:**
Katherine Kinsley-Momberger

**Design and Illustration:**
Katherine Kinsley-Momberger
Nancy Schreck

**Writer:**
Cindy Spence

**Web Editor:**
Jewel Midelis

**Copy Editor:**
Bruce Mastron

**Printing:**
StorterChilds Printing, Gainesville

Member of the University Research Magazine Association
www.urma.org

# Reliance on SCIENCE

BY JIM JONES AND ELLEN MARTIN
*Co-Directors, Florida Climate Institute*

*Jim Jones, professor of agricultural and biological engineering.*

Many of the qualities that make Florida an attractive place to live also make it particularly vulnerable to climate change. The state's extensive coastline, natural springs, forests, wetlands, Everglades, coral reefs and abundant fresh water are all at risk due to rising temperatures and seas. In fact, Climate Central — a respected climate information clearinghouse — chose Florida as the state most at risk from the impacts of climate change. The National Climate Assessment — a group of more than 300 experts established by the federal government — also concluded that several Florida cities — including Miami, Tampa and Fort Lauderdale — are among the world's most vulnerable.

The vast majority of Floridians (80 percent) live or work in one of the state's 35 coastal counties, most within 10 miles of the coast. These communities contribute about 79 percent of the state's economic productivity. Most of Florida's coastal cities are now threatened by flooding and storm surges caused or exacerbated by rising sea levels. For example, the 8 inches of global sea level rise since 1900 already produces significant flooding in South Florida during extreme high tides, so called "king tides." As a result, the Miami urban area ranked highest in a global study of asset exposure to surge-induced flood events, at $3.5 trillion. Additional impacts of sea level rise include beach erosion, salt-water intrusion into drinking water supplies and degradation of coastal ecosystems.

These climate-related impacts threaten sustained growth in key sectors of Florida's economy, including tourism, agriculture and trade. In 2015, 105 million visitors came to Florida and spent $81 billion. Tourism generated 17 percent of the state's sales tax revenue and employed nearly 1.2 million Floridians, making it the state's number one industry. Florida's agricultural industries contribute $60 billion to the gross state product and employ 1.35 million full- or part-time workers. Florida's seaports and network of navigational channels are another essential part of the state's economy, moving more than 100 million tons of cargo each year. Cruise ship and cargo activity support

Photos by Hannah Pietrick

*Ellen Martin, professor of geology.*

more than 680,000 jobs and generation more than $96 billion in economic activity.

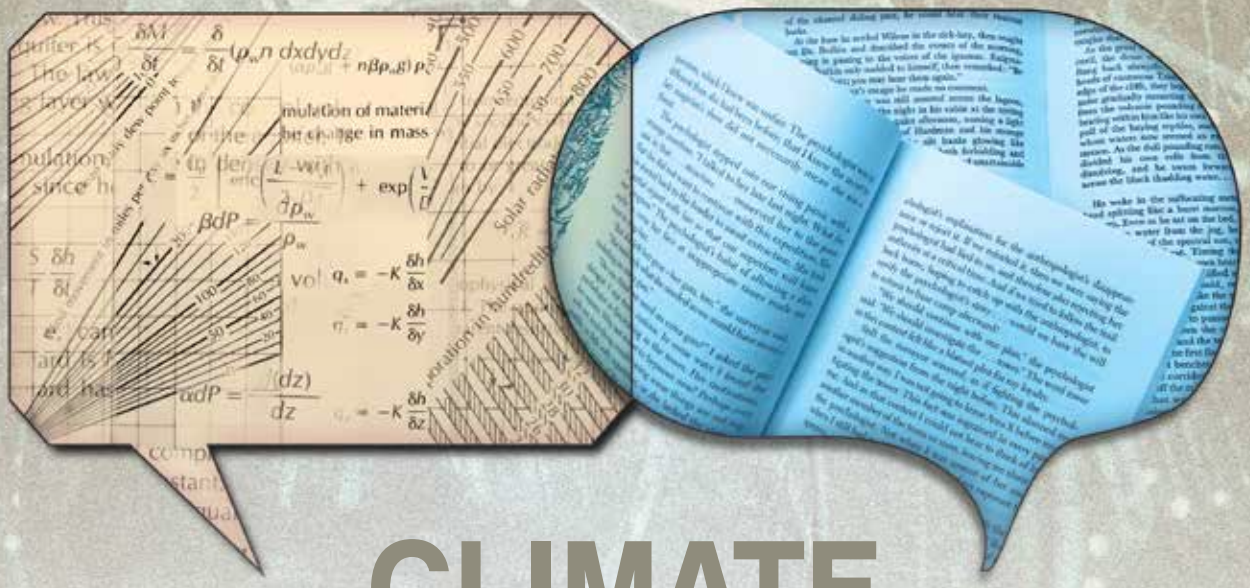
Projections for the future indicate that Florida's annual rainfall could decrease by 10 to 20 percent, and hotter and drier conditions are likely to prevail — with the number of days with temperatures exceeding 90°F increasing from an average of 25 to over 125 in 2050. Tropical storms and hurricanes are also likely to become more intense. Current estimates are that sea level will rise between 1 and 4 feet by 2100, but the potential collapse of the West Antarctic Ice Sheet could cause a much greater increase.

The pace of this change and our ability to prepare and adapt to it are directly linked to our own activities. It is a global problem, but with only 4.4 percent of the world's population, the U.S. emits 15 percent of the world's CO2. While the pace of change is slowest at the national and international levels, many individuals and communities are moving swiftly. One example is the Southeast Florida Regional Climate Compact that calls for Broward, Miami-Dade, Monroe and Palm Beach counties to work together and speak as one voice to coordinate mitigation and adaptation plans in response to climate change.

At the University of Florida, the Florida Climate Institute (FCI) coordinates researchers' efforts to better understand the complexities of the climate system and the risks associated with climate change; develop mitigation and adaptation strategies; and inform and engage elected officials and the public. The institute draws faculty and students from every college at UF and leads a statewide consortium of nine universities to coordinate climate expertise throughout the state.

This issue of *Explore* highlights just a small sampling of the hundreds of initiatives University of Florida faculty and students have undertaken to understand and address the many ways climate change is already affecting our state so that Floridians will have the scientific information needed to make informed decisions.

**Related website:**
https://floridaclimateinstitute.org/



# CLIMATE CONVERSATION

BY CINDY SPENCE

Climate change conversations seem to come with invisible boundaries: humanists talking with humanists, scientists talking with scientists. In some conversations, climate change can be just as taboo as religion, sex and politics.

But how do you tackle a problem you can't talk about?

University of Florida science fiction scholar Terry Harpold wondered if humanists and scientists could collaborate on an unorthodox conversation that could alter the discourse on climate change. He brainstormed with Alioune Sow, director of the France-Florida Research Institute, and an idea took shape.

He called geochemist Andrea Dutton, who had just released a study on sea level rise, with a proposal. If he and Sow could get sci-fi novelists to participate in a panel discussion, would she be the voice for science?

"It was out of the blue," says Dutton, an expert on earth's climate archives, going back millions of years.

Dutton had noticed the same phenomenon: a science conversation going on in the journals, a literary conversation taking place in books and movies, and a public conversation full of dissonance. She signed on.

The experiment took shape as a yearlong symposium series, "Imagining Climate Change: Science and Fiction in Dialogue." The first symposium was in October 2015 with another in February and a March screening of a climate change science fiction film. The series was funded by the French Embassy of the United States, the France-Florida Research Institute and a half-dozen departments in UF's College of Liberal Arts and Sciences. The scope has been international, including scientists and sci-fi authors from France, the Caribbean and the United States and the filmmaker, Wanuri Kahiu, from Kenya.

To Harpold, "Imagining Climate Change" is an invitation to look into the future. As a scholar of science fiction, literary worlds that don't exist don't faze him. The scary thing, Harpold says, is those worlds look less and less like fiction.

"This is an opportunity to talk about how changing the climate changes the human world in every imaginable way."

Harpold says once the scientists and authors got started, the conversations spilled into hallways and persisted through language barriers. One night at dinner, he noticed that UF entomologist Andrea Lucky had been deep in

conversation with Jeff VanderMeer, author of "Annihilation," for 45 minutes nonstop.

"That was an interdisciplinary moment," Harpold says. "That's the conversation I wanted to happen."

As far as Harpold knows, "Imagining Climate Change" is unique, and he thinks there is no better place for the program than UF.

"Where else would it start? We're a land-, sea- and space-grant institution with superb students, superb faculty," Harpold says. "We have an obligation as scholars and as educators — frankly, also as human beings — to be part of this conversation."

Harpold drew students into the conversation with Climate Fiction, a spring undergraduate course. Steeped in ecological sci-fi, the students read nine books that took them into a sometimes hopeful, sometimes dystopian future, among them 1962's "Drowned World," by J. G. Ballard, in which London is under water. In the book, humans adapt to the changed environment by changing, too, at a cellular level.

"We don't worry about whether Ballard gets the science wrong," Harpold says. "What we worry about is what Ballard can tell us about a human life that is transformed by living in a transformed climate, what it means to be human in a place where things have changed so fundamentally that you can no longer continue to live the way you did."

The science fiction boom in the 20th century, with the advent of the space program and visions of aliens and outer space, is fostering a different thought experiment for the 21st century as eco-disasters replace alien invasions.

Unlike scientists, writers can speculate. What are the logical outcomes of the data presented by science? Emotional narrative is not the currency of science, Harpold says, but it may be the "currency that will reach people, to get them to think about whether they want to live in a world that looks like that."

UF President Kent Fuchs spoke at the spring symposium and noted that collaborations of scientists and humanists offer hope: "Scientists can illuminate a great deal about Earth's environment and its changes. They can help quantify our impact and provide wisdom on scientific solutions. But they cannot change our hearts.

"Artists," he said, "can move us."

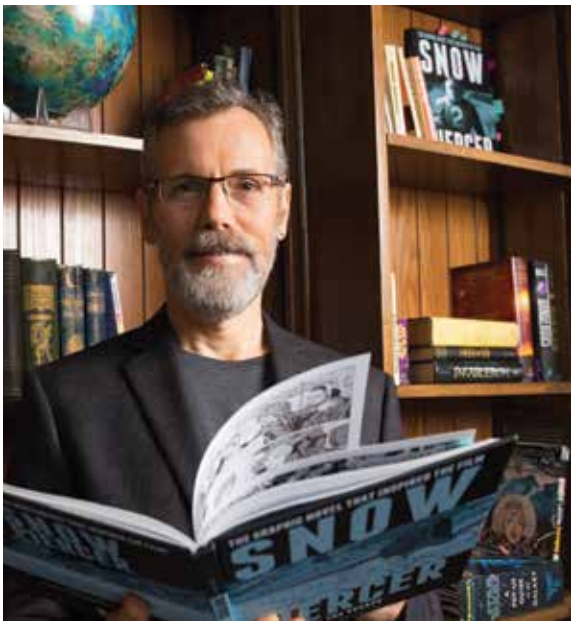
"Imagining Climate Change" will continue into next year. Harpold is in discussion with the Center for European Studies to bring in French and German ecologists in the fall, and eventually he hopes to invite researchers, writers and artists from South America, Africa and Asia to participate. He has petitioned to make Climate Fiction a permanent course offering, and hopes the symposia become the impetus for a research unit for climate and the humanities and perhaps even a research program for doctoral students, hence seeding the future with climate scholars. The focus will remain international; climate change knows no borders.

"Climate change challenges the disciplinary boundaries we believe to be stable," Harpold says. "There's no end to this, no end to what this means for all of us."

UF's breadth of teaching and research, Harpold says, gives it particular relevance for the conversation between the sciences and the humanities.

"We can create widgets, develop information, write books, edit journals, teach classes, but did we do good while we were here?" Harpold says. "At a place like UF, we have the potential to make a new kind of conversation happen about the most important thing we need to do good about.

"We have the luxury of thinking big," Harpold says. "Let's do that."




*Hannah Pietrick*

"Where else would it start? We're a land-, sea- and space-grant institution with superb students, superb faculty. We have an obligation as scholars and as educators — frankly, also as human beings — to be part of this conversation."

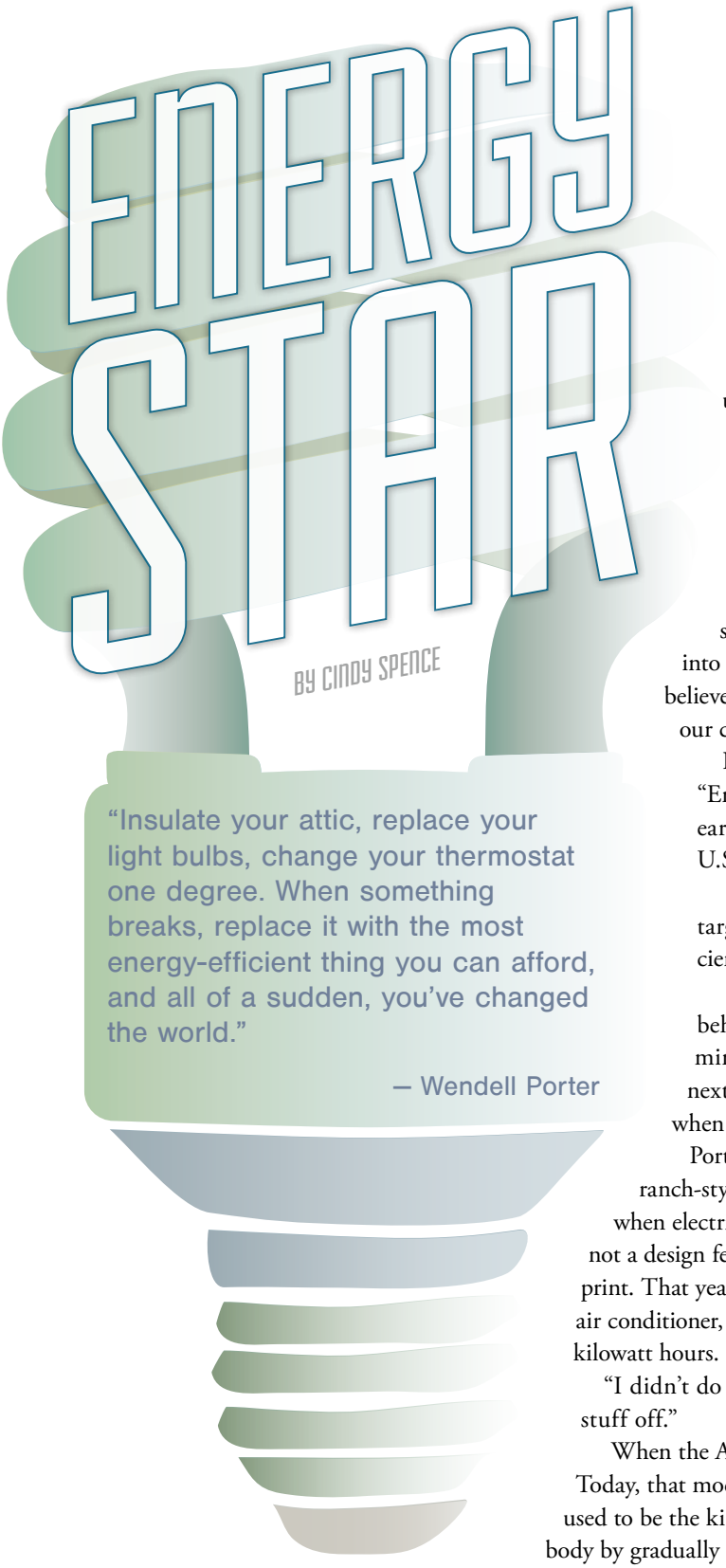
— Terry Harpold

**Terry Harpold**
Associate Professor of English
tharpold@ufl.edu

**Related websites:**
http://imagining-climate.clas.ufl.edu/
http://users.clas.ufl.edu/tharpold/

# ENERGY STAR

BY CINDY SPENCE



"Insulate your attic, replace your light bulbs, change your thermostat one degree. When something breaks, replace it with the most energy-efficient thing you can afford, and all of a sudden, you've changed the world."

— Wendell Porter

Wendell Porter's daughter, Erica, now 27, remembers a childhood where some infractions carried more weight than others.

"I left a light on once," Erica says.

A high crime in the Porter household, with a long lecture attached, Dad armed with data. Today, when she opens her utility bills and compares them to her neighbors' bills, she has two words, "Thanks, Dad."

Porter, a University of Florida agricultural and biological engineering professor, has focused nearly four decades on energy issues. From researching solar panels at UF's Energy Park to teaching AOM 2520 Global Sustainable Energy for UF undergrads to teaching a similar course for 45,000 students around the world online, his work has turned him into a carbon warrior. He says he is a cheerful warrior because he believes that everyone — all 323 million Americans — can change our carbon consumption and change the nation's as well.

Porter pulls a book from his shelf from 1980, simply titled, "Energy." Written in the years after the OPEC oil crisis of the early 1970s, it predicts a future of energy conservation for the U.S. Today, its predictions seem quaint.

"Our energy use is way underneath all the predicted targets," Porter says. "What happened? We became more efficient, and that's a game changer."

Porter says people underestimate the power of personal behavior. For example, he says, one railroad car of coal is 20 minutes of electricity. Something to think about, he says, the next time we leave our cellphone chargers plugged in all day when we tuck our cellphones into our pockets.

Porter uses his own home — a 45-year-old concrete block, ranch-style "energy hog" — as an object lesson. The house was built when electricity was 2 cents per kilowatt hour and energy efficiency was not a design feature. In 2001 he started shrinking his family's carbon footprint. That year, it took 22,000 kilowatt hours to run the pool, the well, the air conditioner, the lights and appliances. Last year, his home used 9,000 kilowatt hours.

"I didn't do anything fancy," Porter says. "Most of that is turning stuff off."

When the AC failed, he bought the most efficient model on the market. Today, that model is so inefficient it could not be sold legally. Porter says he used to be the king of AC; his wife froze all the time. He reprogrammed his body by gradually changing the thermostat one degree at a time over several

Jeff Gage

*Wendell Porter*

months. He plugs entertainment gear into a power strip and turns that off when not in use.

"Unless you really insist on watching Gilligan's Island a minute before it starts, that's fine," Porter says.

He changed the insulation in his attic — about 40 percent of U.S. homes have insulation below code — and switched to LED lights. Ultimately, he plans to install solar panels, buy a power wall with a battery bank for an electric car and unhook from the grid.

"Insulate your attic, replace your light bulbs, change your thermostat one degree. When something breaks, replace it with the most energy-efficient thing you can afford," Porter says, "and all of a sudden, you've changed the world."

And while you're still driving a car with a combustion engine — not much longer, he predicts — you can lower your carbon consumption. Driving sensibly uses less fuel, and that makes it an almost radical act of social change. Porter demonstrates low-carbon-emission driving in a video he filmed for his class.

"Most of our attitudes about energy in this country are sadly just a few years out of date, and a few years makes a world of difference," Porter says. "When we say it's too expensive to make a change, well, no, it's not. The cheapest thing we can do is energy efficiency. You can cut utility use and transportation use in half just by becoming better stewards of your own money. Forget climate, just think about yourself.

"I've never gone into any facility — commercial, industrial or residential — where I couldn't save at least 20 percent without breaking a sweat."

Americans, Porter says, are victims of modernization. Ironically, lack of modernization to date may make the developing world more nimble, more able to take advantage of new energy technologies, much like what happened with cellphones. Whole countries bypassed a telephone system based on landlines and went straight to cellphones. They can do that with energy, too.

"They won't be constrained by 130 years of the power grid as we know it here. There was no model that provided centralized fossil fuel-powered plants and electric lines for distribution for the poorest 2 billion people in the world," Porter says. "But they can go straight to renewable sources like solar."

The rate of growth in solar panels is faster than the growth rate that gave us cellphones, Porter says, with 8,000 megawatts of solar power coming online in 2015. A big power plant generates roughly 1,000 megawatts of power. The U.S. is on track to add 16,000 megawatts of solar this year. With increased demand, Porter expects lower prices and a boom in solar. Coal, he says, "is a dead man walking."

Porter is surprised that climate change, global warming and energy issues are still debated, especially since energy balance in the atmosphere is a matter of math. The first calculations of global warming were published in a paper in 1896 by the Swedish scientist Svante Arrhenius. It might be time, he says, to take it seriously.

"When people say we can't change that fast, I point to history. In 1940, before we entered World War II, this country built 900 military airplanes," Porter says. "In 1943, we built 63,000.

"The amount of progress we've made on energy in the last couple of years — and without a war — is astounding," Porter says. "This idea of rapid change? There's nobody like Americans to do that."

**Wendell Porter**
Professor of Agricultural and Biological Engineering
waporter@ufl.edu


BY CINDY SPENCE

"Water quality problems are growing all over the state. Regulation is coming, landscape ordinances are coming, water restrictions are coming, The most risk-averse thing a developer can do is build green."

— Pierce Jones

In fall 2008, a homeowner in Pasco County was jailed for breaking the rules in his deed-restricted subdivision. His lawn was brown.

A few months later, spring 2009, Tampa Bay Water drained its 15 billion gallon reservoir and crossed its fingers for an early rainy season.

This irony — jailing someone for not using water in the face of a water crisis — is something Florida will need to come to grips with in the face of the double whammy a changing climate and a burgeoning population represents, says Pierce Jones, who heads the University of Florida's Program for Resource Efficient Communities, a research and extension program that supports green building and has worked with communities such as Celebration, near Disney.

Anyone who has lived in Florida for a minute and a half has seen the business-as-usual model of development. Bulldoze a parcel, build a big house on a big suburban lot, throw in a golf course, pave some roads and move on to the next parcel. That model has a carbon footprint the size of Godzilla, according to Jones, who got the opportunity to measure the conventional development model against a resource-efficient model a few years ago.

The developer of Restoration, a 5,187-acre master planned community in Volusia County, approached the Program for Resource Efficient Communities for help in 2006 during a review by the East Central Florida Regional Planning Council. Jones took a look and found a plan for 8,500 homes along with a golf course and suburban-style streets — all in the watershed of Spruce Creek, designated an Outstanding Florida Water for its high water quality.

"This was a standard product, standard Florida practice," Jones says. "I looked at it and knew right away what the problem was — typical Florida sprawl."

Jones suggested a more compact design and mixed uses — which also saved the developer money — and project designer Brian Canin delivered a new design that could be the poster child for more sustainable development.

"The golf course was gone, the roadway system almost cut in half, two-thirds of the land was in conservation," Jones says. "But even better, it gave us two fully developed designs — a before and an after — and we could quantify the differences between conventional subdivision design and green subdivision design."

Road building and maintenance have a huge carbon load. Building a road requires mining materials, transporting them, shaping them into a road, establishing and maintaining rights of way, and at some point in the future, rebuilding. The 2009 redesign cut lane miles from 186 to 103, potentially saving the developer $145 million in road-building costs and keeping 5,855 metric tons per year of CO2 out of the atmosphere.

The compact design, a shopping district and a trolley line from one end of the property to the other reduced the need for auto travel. The estimated savings from the 2006 plan to the 2009 plan: 40,700 metric tons of CO2 per year and a fuel savings of $13 million.

"The savings analysis is highly conservative. Some of the homes might not be two-car homes, for instance," Jones says. "The developer was pleasantly surprised to say the least."

Although construction is on hold, Jones estimates the new design could save the developer $200 million overall and leave an extra $400 a month in

homeowners' pockets due to savings on transportation and other costs of living. That matters, Jones says, because savings for homeowners translates into stability for a community.

"Are these people more or less likely to be able to pay their mortgages, more or less likely to have foreclosed homes?" Jones asks.

Jones' history with green building started closer to home. In 2003, he had a guiding hand in the development of Madera, a green community of 88 homes in Gainesville, where he built energy-efficient homes way above code as a test case. The Program for Resource Efficient Communities owned four of the homes and paid for Madera's engineering. The community is water-efficient and well above Energy Star standards. Even though construction began during the economic downturn, Jones' program made its money back and supported the case for resource efficiency.

"That's how we learned something about development," Jones says.

Water efficiency is one of the foundations for sustainable communities, particularly when it comes to landscaping. Jones says people sometimes view desalination as a solution to water scarcity since the ocean is the source. But desalination, he says, has a giant carbon footprint; it is 20 times more expensive than groundwater because of the energy required to process it.

"Water quality problems are growing all over the state. Regulation is coming, landscape ordinances are coming, water restrictions are coming," Jones says. "The most risk-averse thing a developer can do is build green."

Depending on how it is maintained, a lawn's carbon footprint can be large or small. Under typical turf grass maintenance, the Program for Resource Efficient Communities has estimated the cost per year per 1,000 square feet of lawn: mowing emits 15 pounds of CO2; pesticides emit 1 pound of CO2; fertilizer emits 29 pounds of CO2. Pumping groundwater for a lawn adds 34 pounds of CO2 emissions, but using desalinated water for irrigation adds 579 pounds of CO2 emissions.

Communities built to reduce CO2 emissions associated with the way we live can help the people who move there by reducing commute times and providing green spaces.

"It's not people who are demanding sprawling subdivisions, it's the financial model of developers driving the shape and feel and look of developments. But developers are finally figuring it out," Jones says. "In a climate change environment, developers will have to be smart and make different choices."

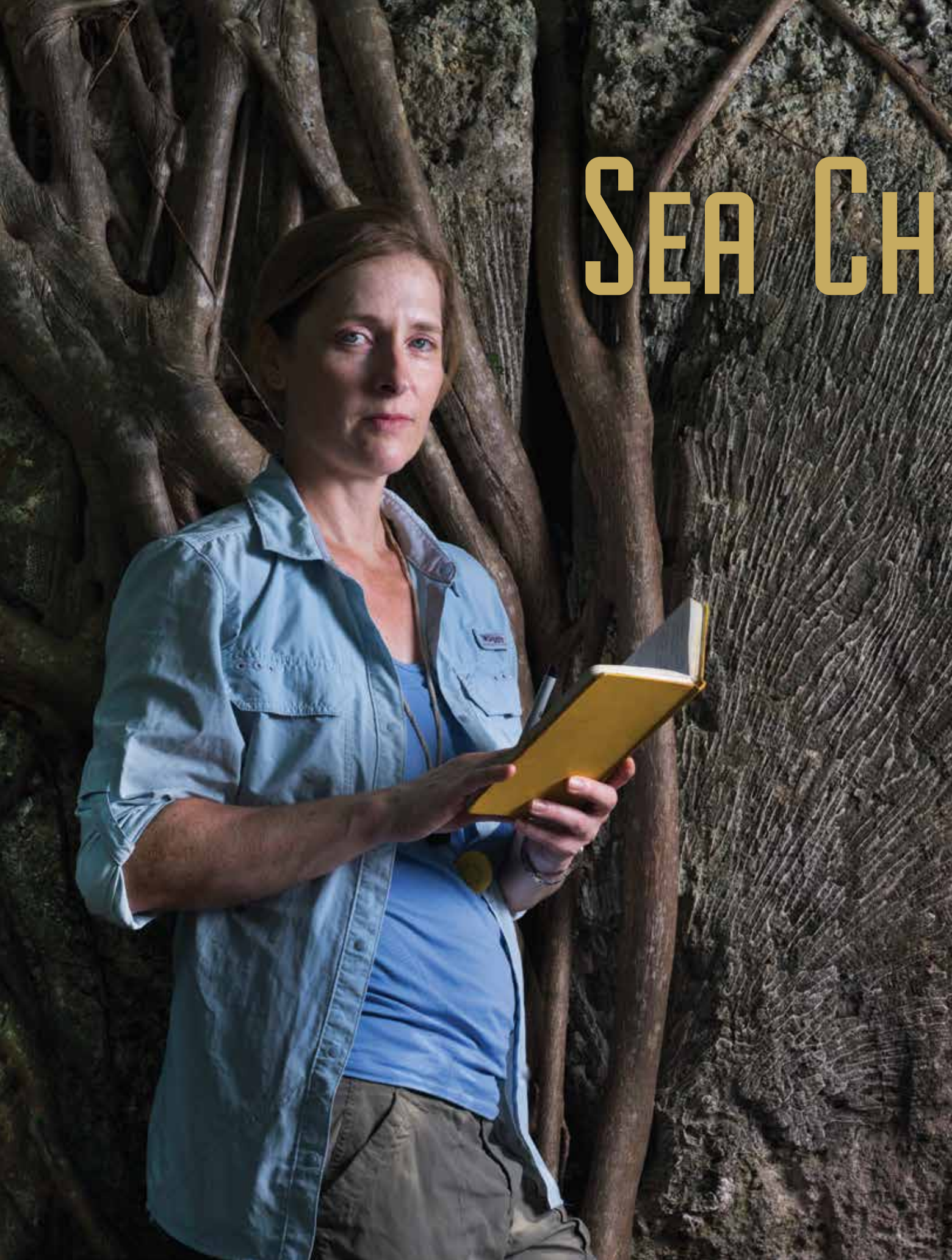
**Pierce Jones**
Director of the Program for Resource Efficient Communities
piercejones@ufl.edu

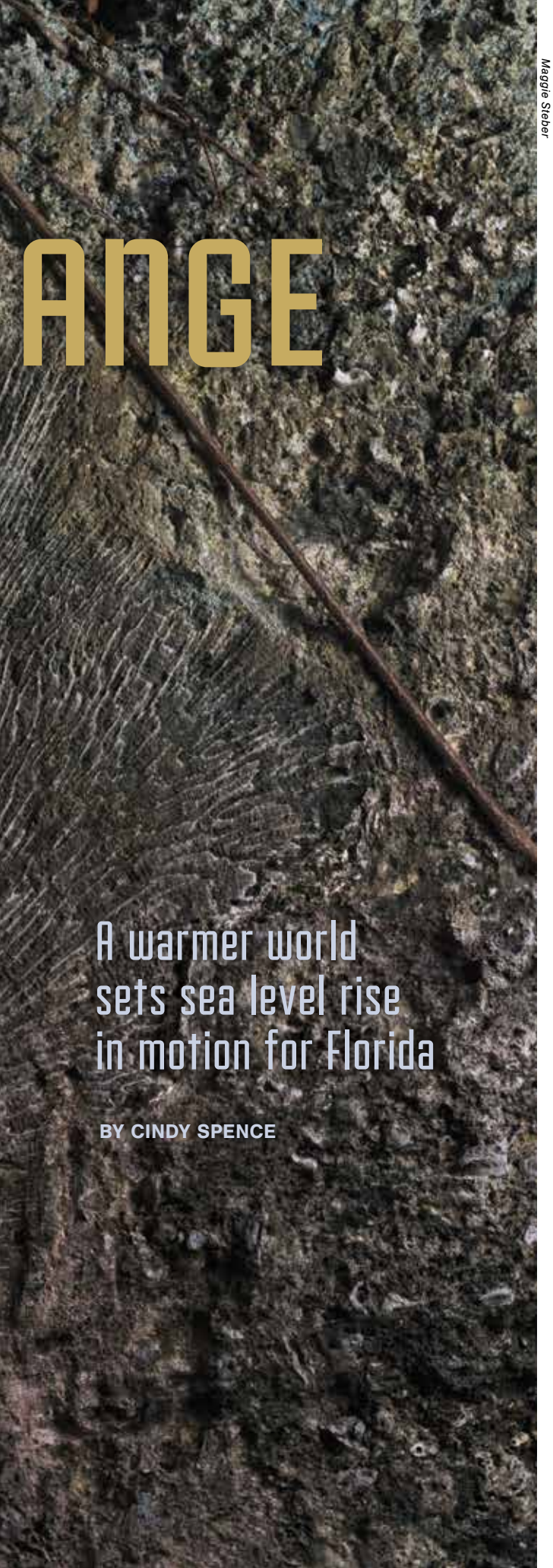
**Related website:**
www.buildgreen.ufl.edu

*Conventional Development*

*Sustainable Development*

*Canin & Associates' 2006 design for a Volusia County subdivision, top, reflected standard practices. The 2009 design, bottom, was more compact, conserving green space, reducing the carbon footprint and saving the developer money.*


Sea Ch



Maggie Steber

# ANGE

## A warmer world sets sea level rise in motion for Florida

BY CINDY SPENCE

Sea level has risen about 8 inches in the last century, and heat records have been broken, only to be broken again, and again.

In human time, this is new, but the Earth has been here before, bathed in a warming atmosphere, and has left clues for scientists like University of Florida geochemist Andrea Dutton. In the rocks is a geologic archive, the history of rising seas, and by following the clues, Dutton hopes to inform the future.

One archive is the Seychelles, the planet's oldest ocean islands along the equator in the Indian Ocean. In 2013, Dutton was examining the islands' fossilized corals, some as much as 130,000 years old, when she got a jolt.

"I found a fossilized coral that was 8 meters above present sea level," Dutton says. "I literally sat down in the field. That's really high, it's 26 feet. I thought, 'People are not going to like this.'"

Her next thought: "How am I going to explain this?"

Current sea level rise is due to thermal expansion of seawater as it heats up and melting of mountain glaciers, and the scientific consensus was that, at current warming trends, sea level would rise 3 to 6 feet by 2100. That estimate includes only a minor contribution from Antarctic ice melt. The only way to explain a water volume that would have submerged the fossilized corals she found, Dutton realized, was ice melt on a massive scale.

Dutton uses temperature to find analogs in the past for today's heat, although the heat of the past occurred without the contributions of 7.6 billion humans. The fossil coral held an ominous message because the coral was found in rock from a period 116,000 to 129,000 years ago known as Marine Isotope Stage 5e, only one degree Celsius warmer than pre-industrial levels.

"People had debated whether the West Antarctic ice sheet collapsed during this time period, and this was one of our first indications that it did," Dutton says. "That was a real eye-opener."

At a temperature roughly as hot as it is today, the Seychelles was under more than 20 feet of water.

At that level, South Florida, the Florida Keys and the Everglades disappear.

*Fossil corals, like these in the Florida Keys, leave evidence of past sea levels for scientists like geochemist Andrea Dutton.*

*Sunny day flooding, like the flooding during this extreme high tide in fall 2015, is becoming more common on Miami Beach, says Florida Sea Grant researcher Thomas Ruppert, pictured here near Biscayne Bay. At right, Miami Beach erected temporary barriers to hold back canal waters and pumped the streets.*

# Water, Water **Everywhere**

Sea level rise is like a flood that never recedes. Think of photos of Hurricane Katrina's aftermath in 2005 — the costliest flood in U.S. history — and imagine if New Orleans still looked like that today.

Now, take a look up and down the coast of Florida, the state with the most people and the most property vulnerable to sea level rise. About 80 percent of the state population lives on a coast, coastal economies are worth $2 trillion, and the coast is not only low but flat, meaning a little bit of sea level rise goes a long way inland. The inlan flow of seawater would soak the limestone sponge that holds about 90 percent of Florida's drinking water, contaminating it.

If Florida is vulnerable, Miami is ground zero, and Thomas Ruppert, a Florida Sea Grant coastal hazard specialist based in Miami, spends his days trying to help local governments address rising seas, doing presentations to share his research and writing.

"My job is to inform and to get them to think about these issues," Ruppert says. "In Miami, you can't talk polar bears. But if you can get

"My job is to inform and to get them to think about these issues. In Miami, you can't talk polar bears. But if you can get local government managers to talk about money, talk about legal liability, that gets their attention. This is going to be expensive."

—Thomas Ruppert

Photos by Florida Sea Grant

Drainage and pumps are extremely expensive, and that brings up the societal cost of sea level rise.

local government managers to talk about money, talk about legal liability, that gets their attention. This is going to be expensive.

"From a citizen's perspective, who do you think is going to pay?" Ruppert asks. "If the local government is paying, that's you. This is going to cost you a lot of money."

Ruppert came to Sea Grant in 2010, when it advertised for an attorney with expertise in coastal planning and zoning. Ruppert had been working with UF's Levin College of Law in its Conservation Clinic, and was well-versed in coastal issues. His legal background is increasingly valuable.

One question he often gets after a public talk is what a citizen can demand of his local government. What is the local government required to do to help him cope with rising water? The answer, quite often, is nothing. Local governments are long on authority to do a variety of things, but are not required to do those things.

"People assume government has to help them," Ruppert says, "and it's not always true."

Take drainage, for example. Local governments do not have to provide drainage. If they do, they are required to maintain what they build, but not required to expand it.

Still, a local government with deep pockets and high-value real estate might decide to improve drainage, and a case in point is Miami Beach, which is spending $400 million to $500 million on pumps after grappling with periodic "sunny day" flooding from extreme high tides. The tide gauge on nearby Virginia Key has registered a 2.5- to 3-inch increase in sea level in just the past 16 years, and that makes drainage, designed to use gravity to take water downhill, an issue. Water, after all, won't flow up. The pumps, 60 are planned, will suck water from the streets and toss it back into the Atlantic Ocean or Biscayne Bay.

Miami Beach is also repaving to raise the level of streets. A Publix that once had seven steps at its entrance, now has two, thanks to higher streets. An almost 100 percent increase in stormwater fees is financing the changes, Ruppert says, and in coming decades drainage will be a multimillion-dollar question for other communities as well.

"If you require local governments to provide drainage in the future that provides the same service as in the past," Ruppert says, "you'd bankrupt some of them."

Drainage and pumps are extremely expensive, and that brings up the societal cost of sea level rise, Ruppert says. The more communities invest in drainage, the less they can invest in education, roads, parks, community centers, the things that make a place worth living in. What happens to communities without Miami Beach's deep pockets?

"In Florida, we're just really unwilling to stop and look at this," Ruppert says. "In a way, the emperor is wearing no clothes in regard to what we're doing on our coastlines."

# Starting a Conversation

Researcher Kathryn Frank has met that metaphorical emperor in her work to help communities plan for rising seas. When she started working in Northeast Florida in 2011, the steering committee for the project shunned the term "sea level rise." Then Hurricane Sandy swept up the East Coast in 2012, taking chunks of Northeast Florida beaches with it. On Sandy's heels, a smaller storm that would have been unremarkable even a few years ago eroded the shore even more.

"They decided to just call it sea level rise, and it was fine," says Frank, an assistant professor in the College of Design, Construction and Planning. "They were ready to start the conversation."

Frank works at the community and regional scale to help communities assess their vulnerability to rising seas and then look for adaptation strategies for economics, safety, natural resources, and heritage.

"They care about all those things, and they want to keep all of them," Frank says.

At UF's GeoPlan Center, Associate Director Crystal Goodison has noticed smaller communities getting started without waiting for someone to tell them to plan. Regional transportation agencies, in particular, are clamoring for information.

Goodison points them to resources on the GeoPlan website: a map viewer that shows sea level rise over time, a wealth of data, and geographic information systems (GIS) software that allows users to create their own sea level rise scenarios using their own data.

## Rising Seas


Land Below High-Tide Line with Five-Foot **Sea Level Rise**

## FLORIDA By The Numbers

**80%** **Floridians** who live or work in one of the **35 Coastal** counties

**1,350** MILES OF **FLORIDA COAST LINE**

**800** **New** Residents to **Florida** DAILY

**105** **MILLION** Visitors to **FLORIDA** in **2015**

**$81** **BILLION** **FLORIDA TOURIST** SPENDING in **2015**

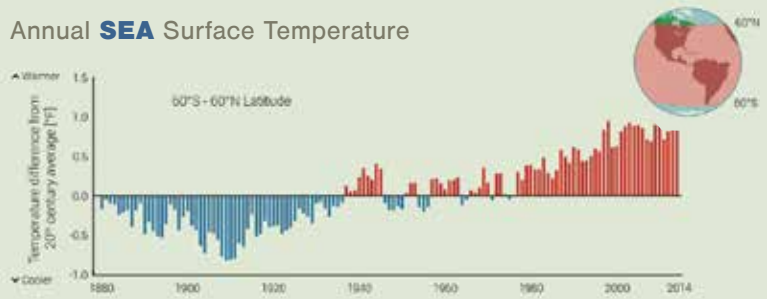
**$60** **BILLION** Economic IMPACT of **FLORIDA** Agriculture

**$2** **TRILLION** Value of **Coastal Economies**

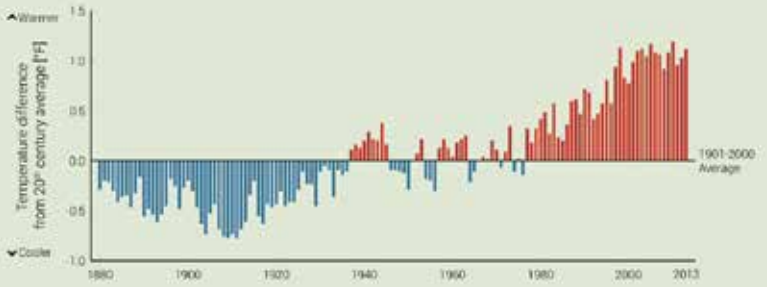
# The **HEAT** is On


*Adapted from climatecentral.org*

## Annual **SEA** Surface Temperature

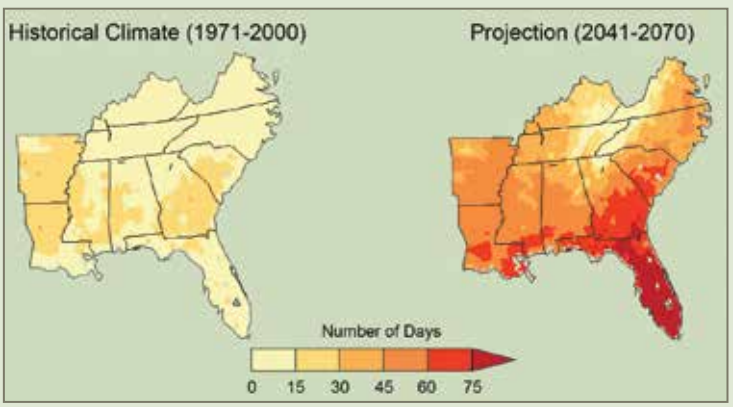



## Annual **GLOBAL** Average Surface Temperature for Land and Ocean



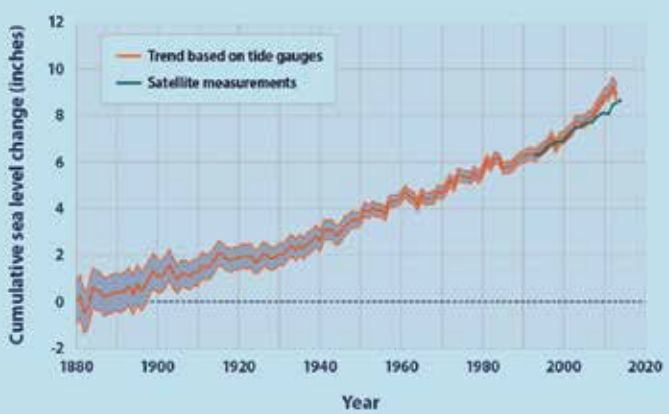

*globalchange.gov*

## Projected Change in Number of Days Over **95°F**




*globalchange.gov*

## Global Average Absolute **SEA LEVEL** Change 1880-2015

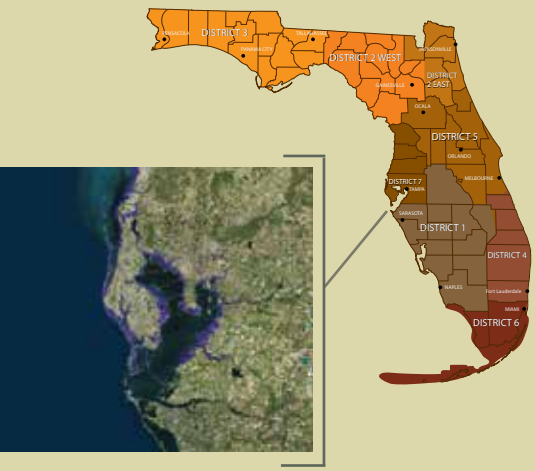



*epa.gov*

## **RECORD WARM** 2015 Across South Florida

| FORT LAUDERDALE (1914-2015) | | MIAMI (1896-2015) | | NAPLES (1943-2015) | | WEST PALM BEACH (1890-2015) | |
|---|---|---|---|---|---|---|---|
| 1 | **78.8°/2015** | 1 | **79.2°/2015** | 1 | **77.7°/2015** | 1 | **78.0°/2015** |
| 2 | 78.3°/2007 | 2 | 78.3°/2011 | 2 | 76.7°/2007 | 2 | 77.6°/2011 |
| 3 | 78.2°/2008 | 3 | 78.1°/1994 | | 76.7°/1946 | 3 | 77.5°/1990 |
| 4 | 77.9°/2011 | | 78.1°/1990 | 4 | 76.6°/1949 | 4 | 76.9°/1948 |
| 5 | 77.7°/2014 | 5 | 77.9°/2013 | 5 | 76.5°/1990 | 5 | 76.7°/2013 |
| 6 | 77.5°/2009 | | 77.9°/2009 | | 76.5°/1947 | | 76.7°/1991 |
| 7 | 77.4°/1998 | | 77.9°/2007 | 7 | 76.2°/1998 | 7 | 76.6°/1998 |
| 8 | 77.3°/2013 | | 77.9°/1998 | 8 | 76.1°/1994 | | 76.6°/1972 |
| | 77.3°/2006 | | 77.9°/1991 | | 76.1°/1991 | 9 | 76.5°/2007 |
| | 77.3°/1990 | 10 | 77.7°/2008 | 10 | 76.0°/2011 | | 76.5°/1982 |

*weather.gov*


*The tools on UF's GeoPlan Center website were developed to help the Florida Department of Transportation determine the vulnerability of expensive infrastructure, such as roads and bridges. The tools, however, are available to anyone to use to map sea level rise scenarios in their own community. http://sls.geoplan.ufl.edu/*

"Think how important transportation is in our economy. If roads come to a standstill, we're not moving people to work, we're not moving freight, we're not moving tourists."

— Crystal Goodison

Brent Farraro

"We accept lifespans in other areas of our lives. There is a different lifespan going on here. Some things we can move, other things we can enjoy while they're here. Sea level is going to keep rising; some places are going to be under water. It's just a matter of when."

— Kathryn Frank

The tools were developed for the Florida Department of Transportation, but are open to anyone. GeoPlan developed an interactive map that allows sea level to be mapped at high, medium and low levels every 20 years from 2020 to 2100, and it allows FDOT to overlay locations of railroads, highways and bridges in making decisions about hugely expensive infrastructure built to last many decades, even into the next century.

"Think how important transportation is in our economy," Goodison says. "If roads come to a standstill, we're not moving people to work, we're not moving freight, we're not moving tourists."

Goodison and Frank say it's heartening to see communities begin to plan, some using new state laws that allow towns to consider adaptation to sea level rise in their comprehensive plans.

Part of building resilience is helping citizens come to grips with uncertainty, Frank says. When will sea level rise, by how much? No one knows. But Floridians don't know when the next hurricane will hit or how strong it will be, and they prepare nevertheless.

"There is so much uncertainty," Frank says. "How do you internalize that way of thinking about the future?"

Frank has worked in the Matanzas Basin on the Atlantic Coast and on the Gulf Coast in Cedar Key, where change washes in on the tide. The town turned to clam farming when its commercial fishing economy was devastated by a state net ban. More recently, its oyster industry collapsed. Cedar Key has been resilient; life has gone on.

Today, Frank talks to Cedar Key and other communities about lifespans. Just as people and pets, houses

and cars, have lifespans, so do communities. Mitigation and adaptation help, depending on how the seas rise.

"We accept lifespans in other areas of our lives," Frank says. "There is a different lifespan going on here. Some things we can move, other things we can enjoy while they're here. Sea level is going to keep rising; some places are going to be under water. It's just a matter of when."

Awareness of sea level rise varies widely, Frank says. Recently, she spoke at Flagler College, which started out in 1888 as the Hotel Ponce de Leon, built by railroad tycoon Henry Flagler. The college is in St. Augustine, which just celebrated its 450th anniversary. A student came up to her afterward.

"He was almost in tears. He got it, cognitively and emotionally," Frank says. "When people get it, it's like an a-ha moment."


Matanzas study area: 1m Sea level rise in 2100

*Kathryn Frank led a study of the Matanzas Basin region in Northeast Florida to help the community determine its vulnerability to sea level rise and begin thinking about adaptation strategies. The study generated maps to model sea level in the future.*

## Money, Money **Everywhere**

In South Florida, where residents witness sea level rise, Ruppert has different conversations. During the last king tide, in October, Ruppert pulled on rubber boots and went to survey the flooding. On a postcard-perfect day, boats were floating at seawall level, cars were marooned, water was gushing up out of storm drains. Along one canal, portable barriers were duct taped together in an effort to keep the canal out of the street. In front of one swamped home, the homeowner ran up to him with a question.

"He wanted to know, 'What are they going to do about this?' Who is they?" Ruppert asks.

For now, pumps and higher streets are the government response. Some residents are elevating homes and building seawalls and crossing their fingers. But seawalls, built on the porous limestone that is Florida's foundation, don't work; water comes up under them. And once your home is elevated, how do you get to it? Seawalls and stilts won't necessarily save the coast.

"One neighbor without a seawall can flood the entire neighborhood," Ruppert says. "Any action at the parcel level is flood mitigation, not adaptation. Adaptation takes collective action at a community or regional level. The approach has to be systemic."

In Miami, in the midst of the South Florida economic engine that funds one third of the state budget, there are resources for sea level rise.

Photos by Florida Sea Grant

*On his tour of Miami Beach during fall 2015's king tide, Florida Sea Grant specialist Thomas Ruppert encountered widespread flooding. Miami Beach is spending $400 million to $500 million on pumps and elevated streets.*

> "Something positive can come out of this if we can actually start a real conversation about public policy, property, the government's role."
> — Thomas Ruppert

At least 30 high-rises are under construction in downtown Miami. But the expense of coping with rising seas is not a burden everyone can bear equally, Ruppert says. Even on Miami Beach, the U.S. Census Bureau estimates 17.5 percent of the population lives below the poverty line. The middle class will be affected when sea level rise affects the ability to insure a home, or sell it.

"Something positive can come out of this if we can actually start a real conversation about public policy, property, the government's role," Ruppert says. "It's an insurance issue, it's a banking issue, it's a local government tax base issue."

Ruppert wonders if a bill is coming due for past coastal real estate booms. So many beach towns, he says, may be a beach in name only in the next century.

"Our barrier islands are a few hundred feet wide in some places. There's no way that's a smart place to build, but there was always so much money to be made," Ruppert says. "We need to realize our actions today set a course for the future."

People ask how to fix the problem, they want solutions. There is no solution, Ruppert says, for the Atlantic Ocean. Sea level rise is like growing old; we know the ending. But people can choose to age gracefully, and Ruppert says communities can choose to adapt gracefully, too. Doing so will just require a much greater level of planning.

## High **Tide**

Florida has been here before, swallowed by a rising sea, and has left evidence behind for archaeologists like Paulette McFadden at the Florida Museum of Natural History. Examining sediment cores in Horseshoe Beach along Florida's Gulf Coast, she found clues to how pre-Columbian inhabitants as far back as 4,000 years ago adapted to sea level rise.

"These people likely had generations of knowledge of sea level rising, so it was ingrained in their culture, the expectation they would have to move. It doesn't mean that places didn't have meaning, that it wasn't sad to lose them, but they had an experience of living on a coast that was changeable," McFadden says. "They didn't have a multimillion-dollar skyscraper sitting on the beach."

McFadden also found evidence in the sediment cores of variability in the rate of sea level rise. In some cases, sea level rose slowly, and the marshes stabilized as they took on more water. In others, sea level appears to have been more sudden.

"We see these punctuated events in these cores, and they correlate closely with the dates of changing settlement patterns," McFadden says. "These populations were much more vulnerable to a large pulse in sea level rise."

That pulse is what Dutton and other geologists want to quantify. Polar ice melting little by little is bad enough. The collapse of a sector of the Antarctic ice sheet into the ocean is another thing entirely.

The West Antarctic ice sheet is larger than Mexico and sits on ground that is below sea level. That makes it vulnerable to a warming ocean, lapping at its edges. The ice sheet, however, is the bulwark for the inland ice mantle. Inland, the ground slopes downward, so without the West Antarctic ice sheet, the warm ocean could spill in.

That kind of ice melt is hard to model, Dutton says, because humans have never seen it happen before, and scientists don't yet understand the boundary parameters or physics that constrain the process.

"The retreat of the ice, especially in Antarctica, could speed up very rapidly. Once it retreats past the grounding line — which some think we have passed — we reach positive feedback: the more ice you melt, the more ice you melt," Dutton says.

"The real question is how fast that process can happen, how fast can this ice discharge into the ocean?"

Geologic timescales get lost in the political cycle. In geologic time, Florida's life above the sea has been very short. But the rocks tell a story about the choices humans have made to sustain life on Earth, and future geologists will find signs of today's choices in the geologic record, perhaps.

"People talk about saving the Earth, saving the planet, and as a geologist you kind of have to chuckle to yourself," Dutton says. "The planet is going to be here, the planet is going to survive.

"Will we?"

**Andrea Dutton**
Assistant Professor of Geology
adutton@ufl.edu

**Thomas Ruppert**
Climate and Policy Coordinator, Florida Sea Grant
truppert@ufl.edu

**Kathryn Frank**
Assistant Professor of Urban and Regional Planning
kifrank@ufl.edu

**Related websites:**
www.geoplan.ufl.edu
https://sites.google.com/site/ufadutton/
https://www.flseagrant.org/climatechange/coastalplanning/
http://staging.dcp.ufl.edu/faculty/kifrank

"We see these punctuated events in these cores, and they correlate closely with the dates of changing settlement patterns. These populations were much more vulnerable to a large pulse in sea level rise."

— Paulette McFadden

*In Horseshoe Cove, on Florida's Gulf Coast, archaeologist Paulette McFadden found evidence of pre-Columbian inhabitants of Florida moving back from the coast in response to sea level rise.*


# Laser Legacy

BY CINDY SPENCE

Since 1859, the Island Hotel has weathered the storms of coastal Cedar Key. Generations have sipped a beer on a hot summer day and dined on speckled trout fresh off the boat. Its weathered facade seems steadfast, a survivor of the Gulf of Mexico's whims.

The thriving inn and restaurant is on the National Register of Historic Places and draws townsfolk and tourists alike. Its place in history is secure, but its place in the next century may not be, and so University of Florida researcher Morris Hylton III points a laser scanner at its walls, documenting it millimeter by millimeter in three dimension.

The images are ethereal, and in a world of rising seas, perhaps the ghosts of Florida future.

The work is part of the Resilient Resources Initiative, and Cedar Key is a pilot before Hylton and his graduate students move on to the 9 square miles of historic districts in Miami's South Beach, and perhaps other coastal communities.

"There are going to have to be some very difficult decisions. Which resources are we going to go to any length and spend any amount of money to save, and what are the things we're going to have to document, and then let go," Hylton says. "The facts are, it can't all be saved."

A 2014 estimate puts 720 of 1,007 UNESCO World Heritage sites at risk from sea level rise. There is no survey of threatened heritage along Florida's 1,350 miles of coastline — although almost any Floridian can name a favorite iconic site — and Hylton says that was the impetus for the Resilient Resources Initiative, a collaboration of the Envision Heritage Program and the GeoPlan Center in UF's College of Design, Construction & Planning.

*Island Hotel, Cedar Key*

*Castillo de San Marcos, St. Augustine*

*Fontainebleau Hotel, Miami Beach*

*The Resilient Resources Initiative uses 3-D visualizations of sea level rise as one way to help historic coastal communities make critical decisions about adapting their buildings or mitigating their loss.*

Hylton says the laser scanning technology gives coastal communities accurate documentation of their heritage as a tool in making the hard choices ahead. UF's laser arrived in 2012, and now the university is a leader in using the technology for historic preservation. Through the National Center for Preservation Technology, the National Park Service contracts with UF to train heritage specialists to document threatened sites, and Hylton's team has been to Thailand and Myanmar to document temples.

When Hylton points the laser at a historic site, a point cloud takes shape in 3-D. The virtual model consists of millions or — depending on the size of the site — tens of millions of tiny points that record the x, y and z coordinates when the laser hits the surface. The files are large, and Hylton says UF's supercomputers, HiPerGator and HiPerGator 2.0, have been pressed into service for data management. HiPerGator's keepers welcomed the opportunity to work on large visual datasets as opposed to traditional datasets of numbers and words. For an archive, digital files are a challenge, Hylton says. Data stored on floppy disks in the 1990s, for instance, is not easily accessible today.

The laser works fast, and speed is what Hylton needs with the sea rising, steadily in some places but unpredictably in others. He estimates it would take a day and a half to document a structure the size of the Castillo de San Marcos in St. Augustine, for instance. The Castillo is the oldest masonry fort in the continental United States, at 321 years old. Although it never fell to an enemy in battle, it is slowly succumbing to the sea.

The technology is as accurate as it is powerful. When interiors of the former Steinway & Sons piano company in Manhattan were

"We have the potential to create a record of the things we are going to lose to sea level rise, to have them virtually, so we can recreate them, or elements of them. It's a very powerful technology."

— Morris Hylton

*The decorative plaster ceilings of the historic Steinway & Sons Piano Company were scanned with a laser. The images were used to recreate the details by hand using traditional methods.*

demolished to make room for a residential tower, Hylton's team scanned the decorative plaster ceilings. Using the scan, the American College of the Building Arts in Charleston, S.C. recreated some of the details by hand with traditional methods.

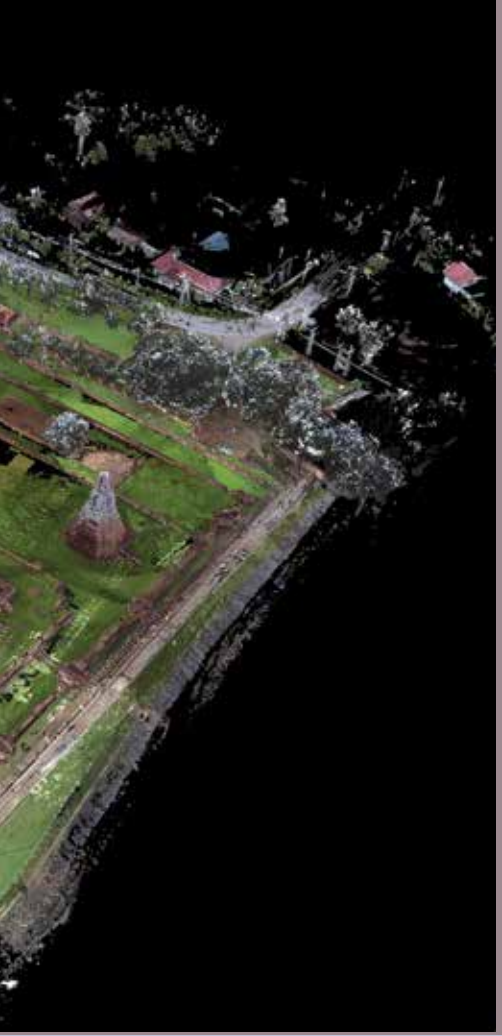
"We went from analog to virtual and back to analog," Hylton says.

"We have the potential to create a record of the things we are going to lose to sea level rise, to have them virtually, so we can recreate them, or elements of them. It's a very powerful technology."

Recreating something larger requires a cost-benefit analysis. A U.S. Department of the Interior study of just one-third of the national parks threatened by sea level rise estimated $40 billion in resources are at risk. The study noted that rebuilding the Castillo farther inland — with its original coquina blocks and tabby mortar — could cost billions.

The National Park Service has partnered with UF to provide training and workshops on using the laser to document its sites. The World Monuments Fund, too, has called upon UF to document fragile resources. When he worked for the fund before coming to UF, Hylton says the enemies of historic preservation were largely decay, neglect, even development. Today, water is by far the major threat.

At Wat Chaiwatthanaram, a riverside Buddhist temple in the Khmer style in Thailand, Hylton's team was invited in following flooding that damaged the foundations of the temple and towers.




▲ *Hylton demonstrates laser scanning at a Buddhist monastery, another cultural heritage site, in Myanmar.*

◀ *Wat Chaiwatthanaram, a World Heritage site in Thailand, is surrounded by 9-foot walls, which were breached by floodwaters in 2011. The Envision Heritage team scanned the site and provided a topographical map accurate to within ¼ inch to help engineers figure out how to manage the flooding, a direct result of sea water creeping up the river bordering the temple grounds.*

Some sites have turned to mammoth engineering to keep rising water at bay. Venice, Italy just completed the Moses project, a series of gates to block the highest tides in the lagoon, at a billion-dollar cost.

"They don't know if it's going to work or for how long," says Hylton, who lived in Venice for a year. "It started so long ago, and today the scenarios are worse than anticipated. It's a World Heritage City, it's one of those places … how much money are we willing to spend to save a place that's irreplaceable?"

As he prepares to document Miami's South Beach and its art deco treasures, Hylton wonders if generations to come, more accustomed to virtual worlds, may turn to the scanned images as a memory bank of sorts. In a future, virtual world, perhaps they can even enter digital images, for a stroll along the ramparts of a fort built by Spanish conquistadors or through the lobby of Miami Beach's Fontainebleau hotel, or into Ernest Hemingway's home with its six-toed cats in Key West.

"Nothing can replace visiting a place, being there, but the fact is we're going to lose a lot of places, and if they can somehow experience them that's a huge benefit from what we're doing," Hylton says.

Hylton has dedicated his career to historic preservation, and says the prospect of what Florida, his adopted home, might lose exacts an emotional toll that is hard to describe. At the same time, he feels an urgency to deploy technology, to do what he can.

"This is critical. We have to do it, or we're not only going to lose these historic coastal places of Florida," Hylton says, "we're not going to have a record."

**Morris Hylton III**
Director of the Historic Preservation Program
mhylton@dcp.ufl.edu

**Related website:**
http://staging.dcp.ufl.edu/historic-preservation/envision-heritage-initiative

# BIG BEND LABORATORY

BY CINDY SPENCE

The Big Bend along the Gulf of Mexico is the least developed coastline in the lower 48 states, 150 miles of fishing villages and stands of coastal forests, a slice of Old Florida forgotten by real estate booms.

The limited influence of humans makes the Big Bend an ideal natural laboratory, and University of Florida researcher Jack Putz has studied its coastal forests since 1992. In 2014, he handed his data over to doctoral student Amy Langston, who quickly came to view the area as a treasure.

"This area is ripe for research on climate change," says Langston, who works with adviser David Kaplan in the Center for Wetlands and is a student in UF's Engineering School of Sustainable Infrastructure and Environment. "This area is so protected, so naturally preserved. Here we can study the effects of climate change — sea level rise, changing temperatures, storm surges, increased frequency of storm events and more extreme weather events — without the confounding effects of human influences. We can see how climate change naturally affects the coastline.

"We don't have many spots where we can see the effects of climate change on natural landscapes, so that's definitely a treasure," Langston says.

For a state that gets more than 800 new residents every day, it might seem that condos and roads, golf courses and shopping centers would be the main threat to coastal forests, but Putz says the killer of acres upon acres of trees in this region is salt.

"Tree deaths are really widespread up and down the coast, and the fact that the forest is retreating so rapidly is an issue," Putz says.

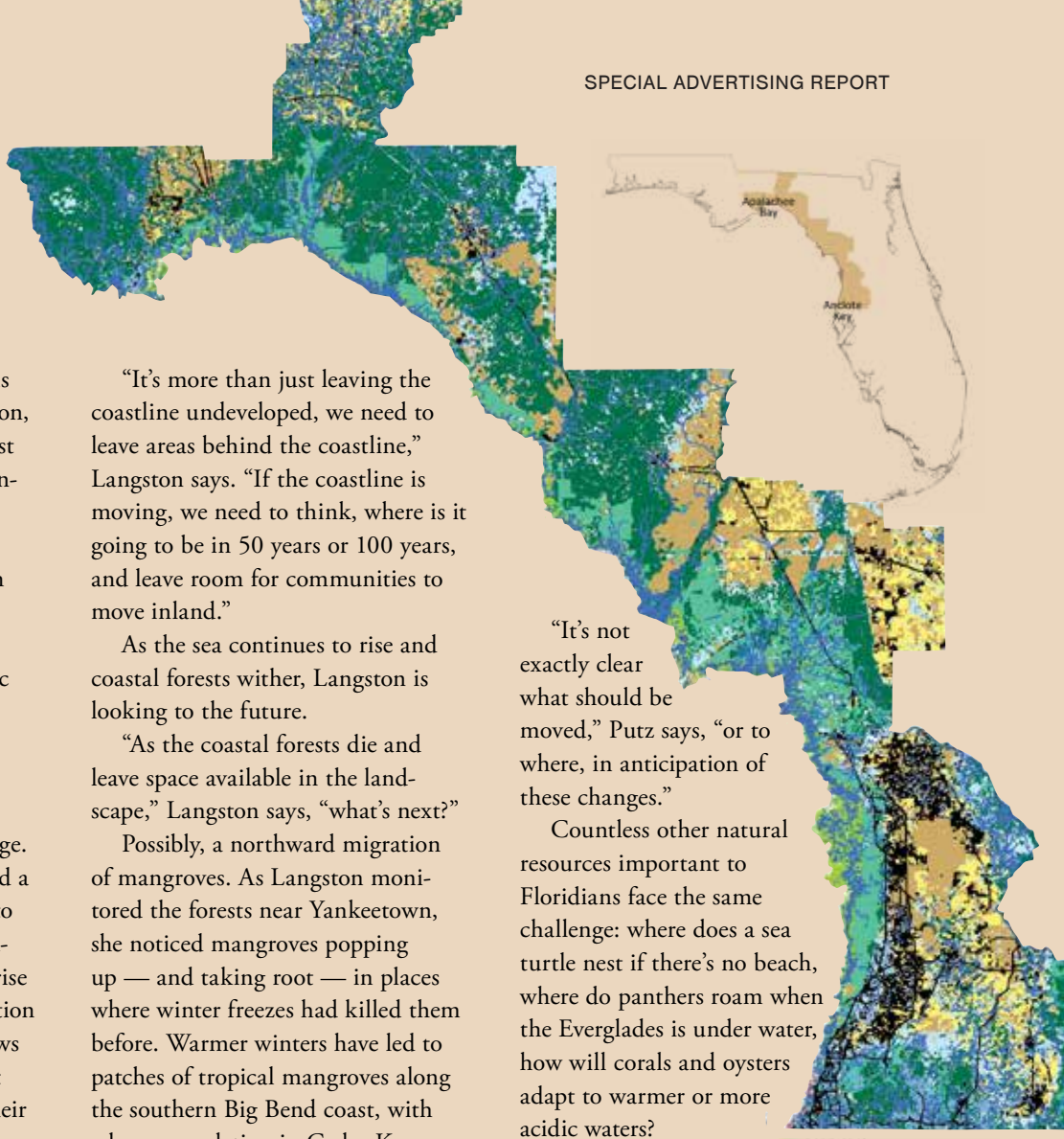
Putz was pulled into coastal forest research in 1992 when a plastic surgeon with a vacation home near Yankeetown called him. The doctor wanted to know why his palms were dying. Putz and a team of researchers drove over to take a look. When they ruled out insects and diseases as root causes, they expanded their investigation.

The researchers established sample plots in which they mapped the trees and measured them, and then tracked what happened. They realized elevation played a role, but they were not sure if the problem was water or salt. Another researcher did a series of experiments with small trees in kiddie pools, varying salinity pool to pool.

"Plants that were flooded frequently were fine," Putz says. "It was the salt that did them in."

The research team compared the records from their sample plots with weather patterns and found that peaks in tree mortality were associated with storm surges that were followed by drought. Although the salinity of the Gulf is only about 18 parts per thousand (compared to 32 parts per thousand in the Atlantic Ocean), as the seawater evaporated, the salt concentration increased to the point that no trees could survive.

"This area is so flat and so low that it doesn't take much sea level rise to inundate a fair bit of forest," Putz says. "Centimeters matter in that landscape."




Putz was overwhelmed with his work on tropical forest conservation, so he handed over his Florida coast data to Langston. Langston continued the studies, finding the same accelerated decline in the coastal forests, but added new work, both across a broader landscape and in Yankeetown.

With UF's Conservation Clinic in the Levin College of Law, Langston worked on the science portion of a two-part plan that makes Yankeetown a statewide model in addressing climate change. Yankeetown, population 502, used a 2011 state law that allows towns to consider natural resources in land-use planning to address sea level rise with a Natural Resources Adaptation Action Area. The policy tool allows communities to take into account vulnerability to sea level rise in their development patterns, infrastructure and other resources.

Yankeetown already had recognized the value of its natural resources. When the plastic surgeon's property was slated for development, the town bought it and turned his vacation home into an environmental education center as part of the Withlacoochee Gulf Preserve.

"Yankeetown has a shot at adaptation, it's ahead of the curve in planning," Langston says.

The science team recommended enhanced natural shorelines and limited coastal development, maintaining the preserve and working with adjacent open spaces managed by other groups to provide a natural corridor for upslope migration of people, plants and animals.

"It's more than just leaving the coastline undeveloped, we need to leave areas behind the coastline," Langston says. "If the coastline is moving, we need to think, where is it going to be in 50 years or 100 years, and leave room for communities to move inland."

As the sea continues to rise and coastal forests wither, Langston is looking to the future.

"As the coastal forests die and leave space available in the landscape," Langston says, "what's next?"

Possibly, a northward migration of mangroves. As Langston monitored the forests near Yankeetown, she noticed mangroves popping up — and taking root — in places where winter freezes had killed them before. Warmer winters have led to patches of tropical mangroves along the southern Big Bend coast, with a large population in Cedar Key, she says. Her hypothesis is that the coastal forests may be replaced in part by mangroves, and that mangroves would preserve some of the forests' ecological functions, such as bird nesting sites or erosion protection. For mangroves, ripped out along other sections of Florida coasts for seawalls, the northward migration could prove healthy, especially since the salt water of rising seas will not hurt them.

"These are two very different responses to climate changes, the coastal forests dying and the mangroves migrating," Langston says.

The coastal forests may follow the example of the mangroves and migrate inland, and Putz says some researchers talk about assisted migration.

"It's not exactly clear what should be moved," Putz says, "or to where, in anticipation of these changes."

Countless other natural resources important to Floridians face the same challenge: where does a sea turtle nest if there's no beach, where do panthers roam when the Everglades is under water, how will corals and oysters adapt to warmer or more acidic waters?

For the coastal forests, slow to migrate, it's a keen question. Their life or death is a snapshot in a history-of-the-earth timescale. But those who are here to witness a natural system as it evolves perhaps have a responsibility, Langston says.

"Maybe because we do have the chance to study this now, we can do something good with the data, better understand the processes," Langston says. "Maybe that's a small silver lining."

**Francis E. "Jack" Putz**
Professor of Biology
fep@ufl.edu

**Amy Langston**
Doctoral Student
amylangston@ufl.edu


John Jernigan

Clyde Fraisse

# SmartFarm

BY CINDY SPENCE

Clyde Fraisse is eager to talk to farmers about climate change. Farmers? Not so much.

"They are very focused on this season," says Fraisse, an associate professor of agricultural and biological engineering at the University of Florida and director of the Southeast Climate Extension project. "They are not as concerned, yet, about the end of the century."

As he looked for ways to start a climate conversation and keep it going, Fraisse came up with a solution: an app.

What started with a single app has now become a suite of apps that monitor weather conditions and disease threats and offer daily summaries. They can be tailored to one field, taking into account soil type, crop, planting date, and irrigation management, and offer alerts based on these conditions. For strawberry disease alerts, air temperature and leaf wetness duration are updated every 15 minutes, offering nearly real-time notifications of disease risk levels. In case of moderate or high risk the app asks a few questions, and based on the answers, offers advice on whether to spray fungicides or not. For weather data, the apps rely on UF's 41 stations in FAWN, the Florida Automated Weather Network and five additional stations that were installed to better cover strawberry production regions of the state. So far, Fraisse's team is up to nine apps, and counting.

The apps are a powerful farming toolbox that can travel in a farmer's hip pocket into the middle of a field, where he or she can access data and make decisions on the spot.

"Farmers want this information on their cellphones," Fraisse says. "They don't want to wait to go home and open up the computer. And they don't have to."

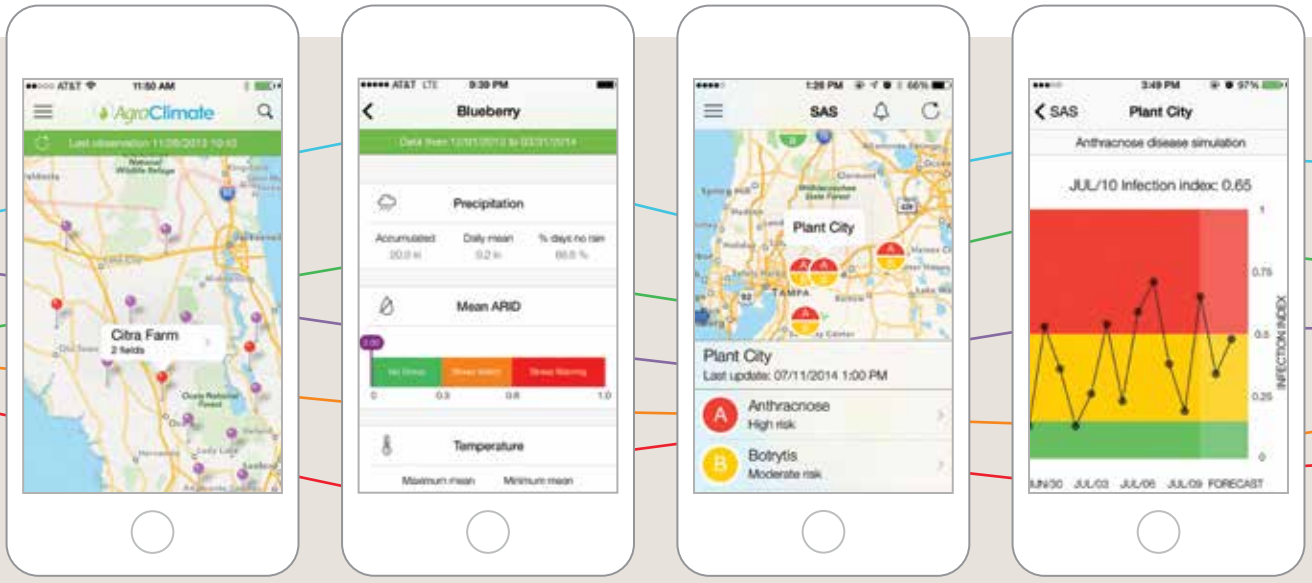
Information is the lifeblood of farming, but it's also a key to adapting to climate change, Fraisse says.

"There is a current push for sustainable intensification of agriculture, to produce more with less in order to feed a global population of over 9 billion people by 2050," Fraisse says. "If we don't incorporate climate science in the process we cannot do that."

The tools Fraisse and his colleagues have worked on, available at www.agroclimate.org and by app, became so popular that he had to overhaul the database. Now, a new state can join and be added in a week. A blueberry advisory system will be added soon, and a team is working with gridded data from NOAA, the National Oceanic and Atmospheric Administration, to offer finer detail. The tools are so popular that the USDA, which funded the original Southeast Climate Extension project at $5 million, has asked Fraisse to adapt the AgroClimate app for Nebraska. A pilot project is in place in Mozambique as part of the Institute of Food and Agricultural Sciences' international program and the team has been invited to Kenya this summer.

The value of the tools is they can be used right now, and that value grows in leaps and bounds as data are added. Farmers will be able to make adjustments in the decades ahead based on the database as it grows.

"If you're a farmer, increasing your resilience is a win-win," Fraisse says.




*AgroClimate information is available on the website — www.agroclimate.org — and through apps for Android and iOS.*

"Whether you believe in climate change or not, whether you believe we are causing it or believe it is natural, it doesn't matter."

While croplands are not a carbon sink such as forests, per se, adding organic matter to the soil improves soil quality while sequestering some carbon from the atmosphere. Improved soil quality can increase water holding capacity, helping crops withstand longer dry spells and increase the infiltration that helps with more frequent extreme rainfall events. "This is good for you," Fraisse says.

"Climate can be part of the decision tool set, even if it's not part of the strategy for this season."

The most popular tool this winter has been the chill hours tracker. Temperate fruits such as strawberries, blueberries and peaches all need chill hours in the winter months to grow healthfully until harvest. December, however, was so warm there was basically no accumulation of chill hours. That may be a seasonal blip, but by collecting data over decades, farmers can determine if it's a trend, and if so, change to a low-chill variety more suited to warmer winters.

Extreme weather events — droughts and excessive rainfall, for example — also focus farmers' attention on potential climate extremes. Severe storms open a door to discussion about the future, something Fraisse accommodates with events like field days and a yearly climate adaptation exchange that started in 2012 in Quincy and is set for this summer in Citra at the UF/IFAS Plant Science and Education Unit.

Fraisse says some of his best conversations come at small farm trade shows, where growers can test the tools and ask questions. Organic farmers for example, pay close attention to monitoring systems, because once a problem is established in their crops, they have no chemicals to take care of it.

Another area Fraisse has worked on is the carbon footprint of a crop. Production, storage, and transportation of a pound of strawberries in Florida, for instance, emits about 0.7 pounds of $CO_2e$ (carbon dioxide equivalent), under some assumptions, such as traveling from Plant City to Atlanta. The assumptions can be changed by users of the AgroClimate web site, allowing them to evaluate the impact of alternative production practices and transportation distances on the carbon footprint.

A precise carbon footprint would require very detailed information, Fraisse says. For example: Is irrigation diesel-powered or electric, and if electric, is it powered by coal or hydropower or nuclear or natural gas? How far did the crop travel, and how many boxes were on the truck, or train? How much nitrogen was used to fertilize?

In the future, if farmers seek carbon credits for reducing greenhouse gas emissions, those calculations may become worthwhile, Fraisse says, maybe even worth developing an app.

"Increasing climate literacy is the first step," Fraisse says. "I think our farmers in Florida are much more climate literate than they were 10 years ago."

**Clyde Fraisse**
Associate Professor of Agricultural and Biological Engineering
cfraisse@ufl.edu

**Related website:**
www.agroclimate.org

# DISEASE DEFENDERS

"THE DISTRIBUTION PATTERN OF MOSQUITOES AND THE DISEASES THEY CARRY IS DETERMINED BY A NUMBER OF FACTORS. THE WARMING OF TEMPERATURES IS ONLY ONE ASPECT."
— JORGE REY

BY CINDY SPENCE

A warming world is turning some exotic names — Zika, chikungunya, vibrio, ciguatera — into household words. But before we sound alarms, University of Florida researchers have some advice: common sense may be our best defense.

Scientists at UF's Florida Medical Entomology Laboratory (FMEL) in Vero Beach and the Emerging Pathogens Institute on campus are keeping a close eye on the effects of warmer temperatures on pathogens, mosquitoes, diseases and toxins. Some maladies have a temperature component; the hotter is gets, the more concern they cause.

Heeding the advice of our mothers, and grandmothers, may be the best way to stay safe. Jorge Rey, director of the FMEL, says protecting yourself from a mosquito-borne disease like Zika virus or chikungunya virus means protecting yourself from a mosquito bite the old-fashioned way. Avoid leaving standing water for mosquitoes to breed, wear sleeves and use mosquito repellent.

*Jorge Rey*

In the meantime, researchers at the FMEL have applied for grants from the National Institutes of Health to dive into Zika research. Zika is scary because of its connection to microcephaly, or smaller brain size, in the babies of women exposed to it in the first trimester of pregnancy. The *Aedes aegypti* mosquito that carries Zika is common in South and Central Florida and has been found as far north as the Panhandle, Rey says.

The impact of warmer temperatures on Zika is not yet known, Rey says. Warmer temperatures will not necessarily change the range of distribution of mosquito species, but it may shift those patterns, he says.

"The distribution pattern of mosquitoes and the diseases they carry is determined by a number of factors. The warming of temperatures is only one aspect," Rey says.

Some of the lessons learned in studying chikungunya and dengue may apply to Zika, Rey says. For example, populations of mosquitoes of the same species differ in their ability to transmit chikungunya and dengue. Whether that will be the case

with Zika remains to be seen. Rey says the FMEL, which has the largest staff of medical entomologists under one roof in Florida, also will examine whether other mosquito species can adapt to carry Zika and other viruses.

Bacteria and toxins also cause concern as temperatures rise, says J. Glenn Morris, director of the Emerging Pathogens Institute. The main concern in Florida is *Vibrio vulnificus*, which caused 45 infections and 14 deaths last year. *V. vulnificus* can enter the body in two ways. A person eating raw or undercooked oysters, for instance, can develop a bloodstream infection through the gastrointestinal tract. And swimmers with an open wound can be infected with the bacteria. In both cases, immune-compromised people who become infected can go into shock, or even die. Potentially less risky, but also of concern, is *Vibrio parahaemolyticus*, which can cause gastroenteritis associated with eating undercooked seafood.

"*Vibrios* are very temperature-sensitive, so when the temperature goes up even a few degrees higher it results in a significant increase in the growth of the *Vibrio* species," Morris says. "Florida has had this problem in the summer for a long time, but as other months grow warmer, the problem could increase."

Outside the U.S., he says, *Vibrio cholerae* is an issue. Rising water temperatures increase the persistence of *V. cholerae* in water and therefore increase the risk of global cholera epidemics.

Another concern in warmer waters is ciguatera, an illness caused by eating fish that have absorbed a toxin secreted by dinoflagellates that live on reefs. Production of the toxin is temperature dependent. The toxin travels up the marine food chain, as smaller fish are consumed by larger fish, until it reaches game fish, such as barracuda. Eating the toxin causes gastrointestinal symptoms and odd neurological symptoms, such as hot things tasting cold and cold things tasting hot. In a subset of patients in which the symptoms do not resolve, chronic ciguatera syndrome, like chronic fatigue syndrome, sets in. There is no cure.

Morris has studied ciguatera for about 30 years, and said a colleague on a fishing trip once called him to ask if it would be OK to eat the barracuda he just caught. "I told him to throw it back overboard," Morris says. The bigger the fish, the more toxin in its flesh. He estimates 70 percent of the barracuda population has toxic levels of ciguatera.

Finally, heat itself will grow as a human health concern as the climate heats up, Morris says. With its high population of elderly citizens and migrant workers, the state will need to keep an eye on those who are vulnerable to heat stroke, Morris says, noting that Florida is hot — and getting hotter.

**J. Glenn Morris**
Professor and Director of the Emerging Pathogens Institute
jgmorris@epi.ufl.edu

**Jorge Rey**
Professor and Director of the Florida Medical Entomology Laboratory
jrey@ufl.edu

**Related websites:**
http://bit.ly/1QTLDqO
www.epi.ufl.edu

# LONG-RANGE FORECAST

- **Florida has 1,350 miles of coastline**
- **80 percent of the state's population lives along the coast**
- **Global sea level could rise by 3 feet by 2100**

**The Florida Climate Institute – based at the University of Florida – is nine universities working together to provide scientific knowledge about our changing climate.**

**University of Florida**
**Florida State University**
**Florida Atlantic University**
**University of Central Florida**
**University of Miami**
**University of South Florida**
**Florida International University**
**Florida A&M University**
**Florida Institute of Technology**

Florida Climate Institute
floridaclimateinstitute.org

UF UNIVERSITY of FLORIDA
research.ufl.edu