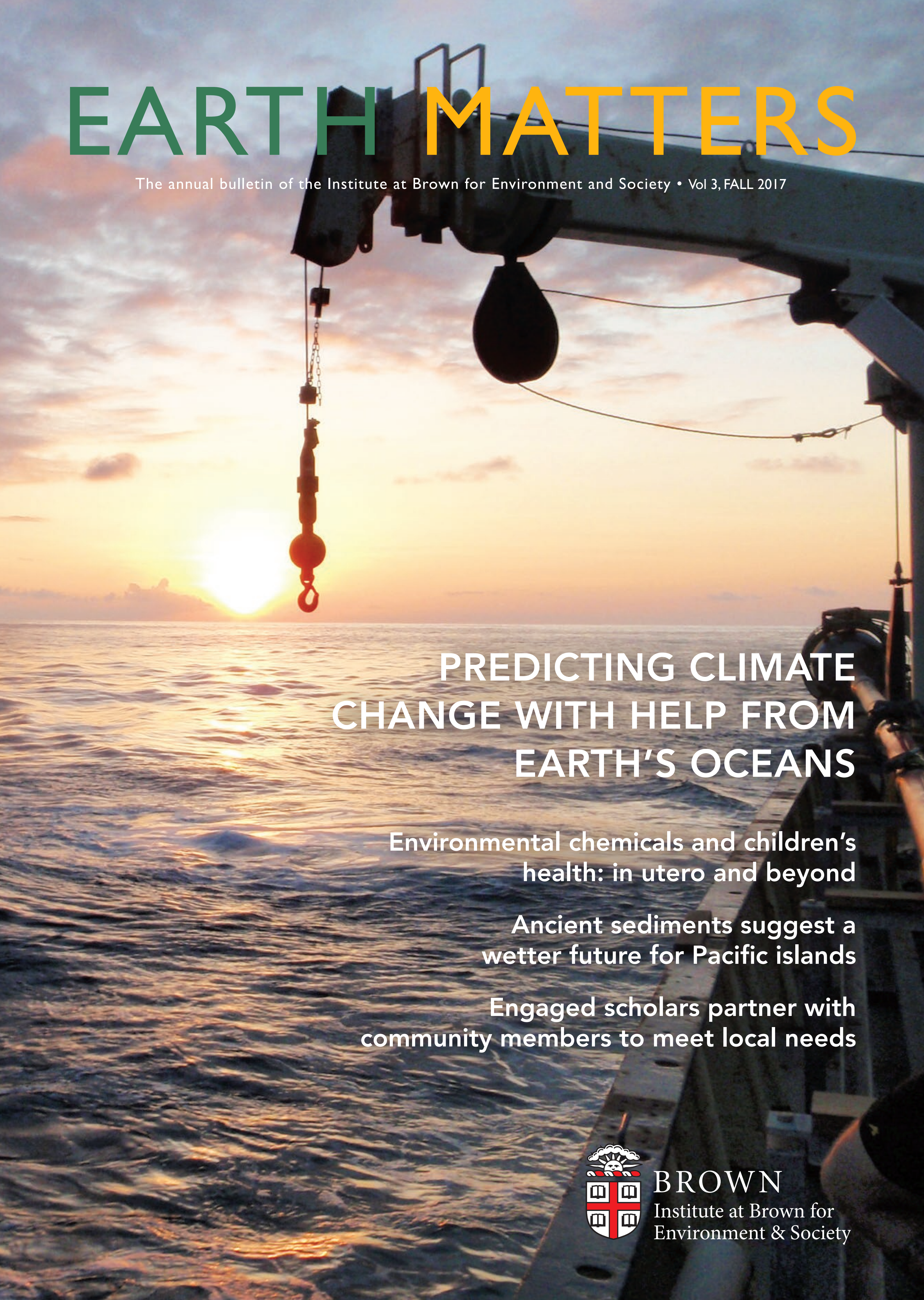

EARTH MATTERS

The annual bulletin of the Institute at Brown for Environment and Society • Vol 3, FALL 2017

PREDICTING CLIMATE CHANGE WITH HELP FROM EARTH'S OCEANS

Environmental chemicals and children's health: in utero and beyond

Ancient sediments suggest a wetter future for Pacific islands

Engaged scholars partner with community members to meet local needs

BROWN
Institute at Brown for Environment & Society

The people and ecosystems of island nations like the Philippines are especially vulnerable to increasingly frequent and intense storms—both inevitabilities of a changing climate. Photo credit: kuroboshi

LETTER FROM THE DIRECTOR

The repercussions of global change and how we respond to it have become a domain of urgency. Why? The greatest impacts of the human imprint on our planet are arising from extremes – heat waves, droughts, floods, and hurricanes. The natural sciences treat the attribution of extremes to human activities as ambiguous at best. But in the public conversation, these events reveal patterns of expectations regarding their scale and frequency; expectations that are being violated with every new disaster, bringing with it the direct experience of the trauma that may lie in the unimaginable future.

It is the increasing number of disasters that lends urgency to calls for binding international agreements that will limit and then eliminate emissions of greenhouse gases. This confrontation, however problematic by the standards of climate change science, is where symbols can be drawn into the service of finding common ground. There is a mounting perception that people across the political spectrum want fundamentally different things, and that the only game is an oppositional one. But perhaps carbon neutral futures can be achieved without needing to agree whether there is a moral imperative to save species or that national security depends on achieving energy independence. Urgency, emergency and crisis – in cultural, political, and economic systems, as well as in the patterns of climatic, ecological, and geological systems – provide us with the opportunity for coexistence.

In 1992, Ulrich Beck wrote, “More urgently than ever, we need ideas and theories that will allow us to conceive the new which is rolling over us in a new way.” As scholars, we understand that it is necessary to integrate where possible and balance where necessary the competing interests at play. For this reason, IBES research is characterized by collaborative empirical approaches that cross traditional disciplinary boundaries. As educators, we work with students to engage with the deep complexity of human-environment interactions. We focus our efforts on vulnerable people and places and commit to the support of human dignity and ecological integrity.

Amanda Lynch, Director

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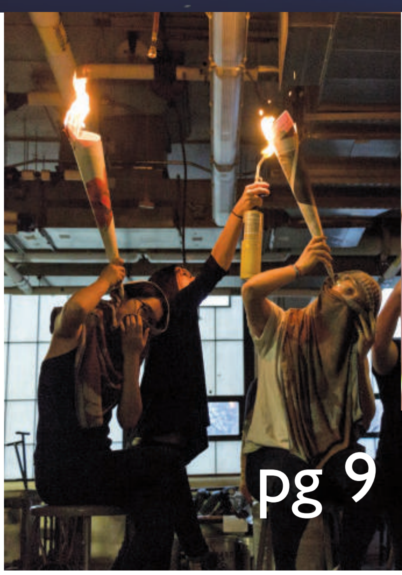


THEME COLOR CODE

- food & water
- health & well-being
- natural systems
- equity & governance

ROLLING IN THE DEEP: INSTITUTE SCIENTIST TACKLES OCEAN'S ROLE IN CLIMATE CHANGE

Chances are, the last time you were at the beach, ocean physics wasn't paramount on your mind. However, that glistening expanse of frothy blue is more than just a pretty sight. In fact, it is one of the biggest drivers of both weather and climate on Earth.

Baylor Fox-Kemper, Associate Professor of Earth, Environmental, and Planetary Sciences, is keenly aware of the ways that the ocean and atmosphere interact to drive both the weather systems of today and the climate change of tomorrow. He and his team study turbulence, the disordered, variable features that participate actively in the transfer of energy, carbon, and heat between the water and air. Their goal is to improve the way our most powerful climate models simulate these features, giving scientists the tools to explore current phenomena and predict future changes in climate.

OCEAN AND ENERGY

Earth's climate is driven primarily by the sun, but it is the large-scale ocean currents and winds that redistribute this solar warming from its area of highest intensity, the equator, to the cooler midlatitudes and polar regions. Most of the absorbed heat of the sun is stored in the oceans, to be released at night or during winter, behavior that adds to the equalizing effect.

But it is actually on the smallest scales that the air and water meet, exchanging heat energy through turbulent features like swirling eddies, small storms, and even spray droplets.

"At any moment in the ocean, there are hundreds of little eddies on any slice across a basin, and they're all kind of mixing and churning and extracting energy," explains Fox-Kemper. "You wouldn't get any air-sea exchange unless you had that kind of turbulence."

In some cases, that turbulence quickly becomes noticeable on macroscopic scales. For instance, the energy stored in warm eddies gradually heats and and humidifies the air above, leading to the formation of clouds and precipitation and generating weather systems that ride along.

"Those eddies can affect local climate intensely," says Fox-Kemper. "If it's a warm eddy, then you'll have a warm atmosphere above. That will be different than having the average ocean temperature exposed to the average atmospheric temperature. And so it has different clouds, it has different precipitation, it has different weather."

Flanders and Frenchman's Bays, as seen from Sullivan, Maine, frame Cadillac Mountain at Acadia National Park.
Photo: Baylor Fox-Kemper

"If you're on a boat and go through one of these, you can tell," he adds. "In a matter of hours you'll go from a cold day to a warm day as you cross over one of these little regions."

THE BRINY RESERVOIR

The ocean's ability to store heat in this way is the primary reason that it has such a powerful impact on both local weather patterns and global climate.

"Water stores heat energy much much more effectively than almost any material we know of," explains Fox-Kemper. "The upper about three and a half meters of the ocean have the same heat capacity as the whole atmosphere—and the ocean is about four kilometers deep."

The ocean's ability to store excess heat will continue so long as liquid water is present on Earth. But the ocean also acts as another storage reservoir, and one that is much more fragile: a sink for carbon.

In fact, the ocean's capacity to store carbon is vital to keeping global temperature changes within a manageable range. As Fox-Kemper explains, the ocean takes up about 90% of the heat energy and half of all the carbon emitted into the atmosphere.

"If all of the excess energy retained by the Earth under global warming was put into the atmosphere only, we would be having double-digit global warming," he says. "What keeps it to just a few degrees, or a degree and a half, is because the ocean takes up the vast majority of the excess energy."

When carbon goes into the ocean, some of it is incorporated into biological forms, such as the cells or shells of marine organisms. The rest of it is dissolved and transformed into chemical compounds, which make the ocean more acidic.

If temperatures rise dramatically over the next few centuries or decades, however, the delicate chemical balance of today's oceans could change. Some sea

Scientists can ask what is likely to happen if societies produce a certain amount of carbon or change their emissions, and obtain a relatively sound prediction of the climate's response anywhere from 10 to 10,000 years in the future.

creatures, such as corals, have evolved in nearly constant temperature environments, so they are very sensitive to changes in temperature and acidity. Coral bleaching and death are closely related to human-induced climate change.

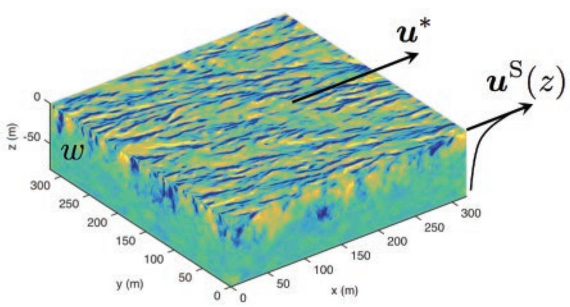
Furthermore, the changing climate may change the capability of the ocean to act as a carbon reservoir.

"The amount of carbon dioxide and carbonate and bicarbonate the ocean can hold is temperature and salinity dependent," explains Fox-Kemper. "So if you change the temperature of the ocean, you might actually release carbon back into the atmosphere."

"Or," he continues, "If you change the pattern of currents, then you might bring up carbon-rich waters into a place where they're triggered into releasing it, rather than taking carbon-poor waters, filling them up with carbon, and then sinking them for a while."

RESOLVING UNCERTAINTY

Although the general impact of these processes is well-known, scientists are still trying to determine their exact effects.



Langmuir turbulence, which is a small-scale form of turbulence, is shown in an upper ocean simulation. Credit: Qing Li, Fox-Kemper Lab

"If you change the climate system, that changes the currents, that changes the air-sea exchanges of carbon—that part, we're still figuring out," says Fox-Kemper. "That's part of why we are moving into a new generation of climate models where the carbon cycle is directly represented."

Climate models have been around for decades; but it wasn't until recently that scientists could start to predict the impacts of individual factors on local climate change. In recent decades, more and more layers have been added to climate simulations—rainfall, snowfall, solar radiation, atmospheric factors, sea ice, land ice, ocean features, the carbon cycle, and more—in an effort to understand how individual processes affect one another in a changing global environment. The ultimate goal is to simulate a very complex system of feedbacks, and the ways in which that system might be sensitive to change.

The result is a sort of 'experimental' version of Earth, which can be tweaked to corroborate short-term observations and predict long-term climate patterns.

"In a model, you can sever connections and see what the consequences are, or add new connections and see what the consequences are," says Fox-Kemper. "That's a very powerful way of exploring how the system as a whole behaves."

It also enables scientists to project into the future and observe many different outcomes, depending on our behavior today. For instance, scientists can ask what is likely to happen if societies produce a certain amount of carbon, decrease or increase their emissions, or switch entirely to renewables, and obtain a relatively sound prediction of the climate's response anywhere from 10 to 10,000 years in the future.

COLLABORATION IS KEY

Fox-Kemper and his team are currently working to accurately represent the effects of surface waves in the Community Earth System Model (CESM), a product of the Department of Energy, the National Center for Atmospheric Research and hundreds of university collaborators. Fox-Kemper himself is Co-Chair of the Ocean Model Working Group, the coalition in charge of optimizing the ocean component within the CESM.

"What our group is trying to do," he explains, "is to make better, more accurate representations of [air-sea] exchanges and turbulence to better quantify how much carbon, how much momentum, how much energy, comes and goes between the atmosphere and the ocean."

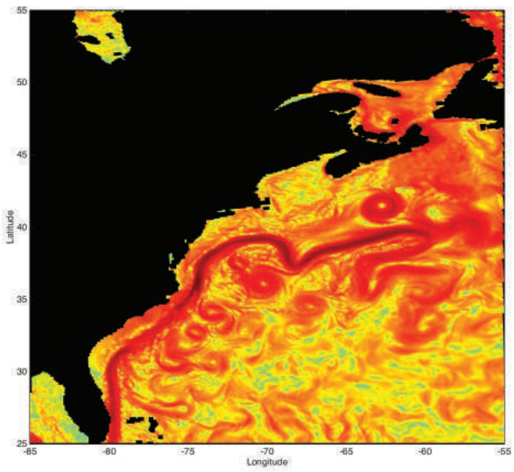
Fox-Kemper explains that this work has greatly improved multiple components of climate models, making them both more accurate and more predictively sound. In some ways, he and his team have been surprised by the results.

"The majority of things that we find out are that certain [ocean] processes are more important to the climate system as a whole than we thought they were," he says.

He is clear, however, that the benefits of climate models go far beyond improving scientists' understanding of the underlying physics.

"Not every impact of climate change on the ocean is related to the ocean's role in the climate system," he says. "A lot of it is also that the ocean is an enormous ecosystem with a lot of diversity, and a lot of people depend on fish for food. And so it has all these socioeconomic, environmental impacts that are separate from its direct effect back onto the climate system."

Reflecting on these impacts, Fox-Kemper suggests that the changing ocean—long a mainstay of geoscientific study—is actually ripe for examination within the interdisciplinary environment of IBES.



Large eddies can clearly be seen in this simulated map of kinetic energy in the North Atlantic. Credit: Brodie Pearson, Fox-Kemper Lab

"It would be nice to have an economic or equity or societal lens on how to think about those problems," he continues. "We're emphasizing the physics, but actually, these are multidisciplinary problems at the root."

The exact effects that a warming world will have on our oceans, or on those who rely on its resources, are as yet unknown; in the meantime, Fox-Kemper and his team are hard at work honing their piece of the climate puzzle. They are resolute in their mission to ensure the accuracy of today's climate simulations.

His explanation is simple: "Since we have only one Earth and we don't care to endanger it by experimenting with it, it would be great if we had models that we could experiment with safely." ■

KIDS AND CHEMICALS: DO THEY MIX? PROBING THE HEALTH EFFECTS OF ENVIRONMENTAL EXPOSURES

Our environment oozes with chemical contaminants. They lurk in our food, our furniture, our cleaning supplies, and our medicine cabinets. But what effect are they having on the most vulnerable among us—our children?

For over a decade, Assistant Professor of Epidemiology **Joseph Braun** has followed hundreds of pregnant women and their growing children in an attempt to determine what, if any, developmental consequences follow from exposure to chemicals in the environment. His results suggest that many of these chemicals do indeed impact children's health; but what happens when they combine, and what preventive actions parents can take, are still open questions.

PERVASIVE COMPOUNDS

Chemical additives are ubiquitous in today's industrialized world. Some, like flame retardants in carpeting, may be required by law. Others, such as scent-stabilizing phthalates in perfumes, are deemed necessary to a product's usefulness. Still others, like pesticides, are vital to maintaining an abundant food supply. But their presence is often less than obvious.

"They're everywhere," says Braun. "That's the thing that makes them most unsettling to a lot of people, particularly the lay public, because we often don't know where they are."

Infants and young children are especially vulnerable to the effects of these chemicals for a variety of reasons. Some are behavioral: babies spend much of their time on the floor, and infants and toddlers explore the world by way of their mouths. Others are biological, owing to fetuses' and children's underdeveloped capacities to detoxify harmful substances.

Indeed, there is mounting evidence that some gestational experiences can and do cause health effects years or even decades after birth.

"There are classic studies from World War II, when women were on starvation rations during the Nazi occupation of the Netherlands," Braun explains. "The children who were in utero during this period of starvation were at increased risk for many chronic diseases later in life."

Braun and his colleagues wondered whether similar associations arose from prenatal exposure to environmental chemicals; but they were also interested in examining effects from exposures that might occur later on, in early childhood and beyond. After all, he explains, an infant's body systems will continue to grow rapidly for the next two decades or more.

And nowhere is this process more vital than in the child's center for executive control: the brain.

"The brain doesn't stop developing the moment the baby pops out of the womb," he says. "It keeps going. There are a lot of events that continue to go on in the brain, well into adolescence and even early adulthood."

DEVELOPMENTAL CONSEQUENCES

In 2003, Braun's colleagues launched the Health Outcomes and Measures of the Environment (HOME) Study. They began by measuring the presence of five neurotoxicants in pregnant women and their children, from birth to 5 years: mercury, lead, tobacco smoke, pesticides, and a class of industrial chemicals called polychlorinated biphenols (PCBs) that were banned in the 1970s but still remain in the environment due to their persistence.

Later, the team added tests for bisphenol-A (BPA), phthalates, flame retardants, and perfluroroalkyl substances such as PFOA, a chemical used to manufacture stain- and water-repellant coatings.

Their findings suggest that some of these chemicals do lead to adverse neurological outcomes in children. For instance, prenatal exposure to tobacco smoke was associated with later alterations in infants' brain activity. The team also observed an increase in behavioral problems in girls aged 2-3 whose mothers had been exposed to BPA, and an increase in autistic behaviors in toddler and young children whose mothers had been exposed to flame retardants and a specific pesticide.

When the team began examining the effect of certain exposures on obesity and cardiometabolic outcomes, more connections began to arise. Mothers with high levels of PFOA tended to give birth to children who gained fat tissue more quickly as toddlers and retained a higher than normal level of this tissue at age 8.

Braun and his colleagues are currently reassessing the children, who are now adolescents, for additional cardiometabolic outcomes including blood pressure and fasting glucose, insulin, and lipid levels.

FIXING THE PROBLEM

So what are concerned parents to do? The good news is that some exposures can be reduced by simple lifestyle changes. For example, consumers can limit exposure to chemicals like phthalates by avoiding the practice of microwaving food in plastic containers, or by replacing plastic stretch film with wax paper. Families can also reduce their exposure to certain pesticides by eating organic fruits and vegetables. Similarly, parents can use water filtration systems as a potential defense against water-borne neurotoxicants like lead that can be found in the water pipes of older homes.

But sometimes, these recommendations come at the expense of larger public health concerns.

"We found that some behaviors like consuming beverages and food out of cans was predictive of BPA levels in the kids," says Braun. "But you don't want people to be replacing the healthy stuff that's in canned foods with junk food."

"Don't replace your kidney beans with cheeseburgers or milkshakes," he laughs. "That's an extreme example, but there's lots of healthy stuff in canned foods."

Moreover, Braun explains, exposure to environmental chemicals is really quite difficult to eradicate completely.

"If you want to avoid all of it, you almost have to disconnect from the modern world," he says. "And I think what that speaks to is that we can't rely on individuals to simply change their behavior to reduce their exposures. We need to rely on policies and interventions from governments and regulators to do something to keep exposures below a level of concern."

Progress on that front is slowly evolving. Under the new Frank R. Lautenberg Chemical Safety Act, signed in June 2016, the chemical industry will be required to conduct pre-market toxicity testing of all new chemicals and to make this information publicly available; however, regulations surrounding the testing itself have not yet been specified, so it is unclear how much of a difference in transparency this new law will make.

"The devil is in the details," says Braun.

EXPANDING IN UNDERSTANDING

Even accounting for additional regulatory oversight, scientists still struggle to understand how all of these different chemicals interact once they combine in children's body systems.

"There's this very large chemical soup that we're exposed to," says Braun. "What's either the joint or cumulative effect of these exposures on children's health? We don't have a good handle on that."

Public health scientists are currently working to develop new statistical methods that will be powerful enough to examine the effects of combined exposures. Until that happens, Braun and his colleagues plan to continue following their cohort of children as they grow. They hope that their results will begin to inform the decisions that both parents and regulators choose to make with regard to environmental chemicals.

"I think what's important about these studies, where we have long-term follow-up, is we really get the chance to see children's trajectory of development, and not only to investigate children's health at one time in life." says Braun. "We can be thinking about children as a dynamic entity that's changing over time, not as this static individual at any one age."

"They're growing in physical size, they're maturing, their brain is growing and doing different things, they're developing new skills as they get older," he continues, "And a lot of it is happening in a very short period of time, so we get to observe it."

Indeed, the same factors that make children most vulnerable to chemical exposures are also those that make this kind of research the most impactful.

"It's quite profound [in children]," he says, "how rapidly things change." ■

Earth, Itself 2017: WHAT FIRE DOES

1. Keynote speaker Pamela Smith discusses fire and transformation in art and alchemy.
Photo: Emilia Figliomeni

2. The John Carter Brown Library joined in the festivities with the exhibit America on Fire.
Photo: Verda Seneor

3. Wendy Woodson returned to this year's Earth, Itself conference to perform her free-association monologue, Fire Away.
Photo: Corey Marsh

4. Panelists discuss fire, unintended consequences, and environmental justice. Photo: Emilia Figliomeni

5. RISD Glass simulates volcano behavior with sand and fire.
Photo: Corey Marsh

Join us for next year's Earth, Itself event in

April 2018

Water's Edge will feature collaborations between the Literary Arts Program, the Bell Gallery, and the John Carter Brown Library. Later activities will take place in September 2018 in conjunction with University of the Witwatersrand, South Africa.

Convened by Lenore Manderson

Earth, Itself 2017, continued

6 & 7. Keynote speaker Stephen Pyne discusses the overabundance of combustion on the Earth today in his lecture, Fire: A Biography.

8. RISD Glass demonstrates a Mexican tradition for healing and purification. Photo: Corey Marsh

9. Artist David Katz discusses his installation Structure and Growth at the RISD Nature Lab. Photo: Verda Seneor

10. IBES fellow Yongsong Huang discusses fire, ice, and the mystery of the first American settlers. Photo: Corey Marsh

11. Playing with fire at RISD Hot Nights. Photo: Corey Marsh

ADVISORY PERSPECTIVE: WHAT MAKES IBES UNIQUE?

The truly, deeply interdisciplinary nature of Brown lends itself to being a scholar and changemaker at once. On campus, you can sense the strong value for and sense of urgency about solving social problems.

The Institute's Advisory Council is a dynamic team of leaders in business, academia, and the non-profit and public sectors—all of whom have a deep commitment to fostering environmental stewardship and sustainability both today and in the years ahead. Many are former Brunonians themselves and speak fondly of their time spent at the University, especially on account of the tremendous diversity of thought and cross-disciplinary focus that Brown is so well-known for.

Bina Venkataraman, an Advisory Councilor who is currently director of global policy initiatives at the Broad Institute of Harvard & MIT and a fellow at New America, is no exception.

"The truly, deeply interdisciplinary nature of Brown lends itself to being a scholar and changemaker at once, being a person who draws on evidence to enact change in the world," she says. "It's reflected in the way that Brown facilitates that exchange across departments and fields, but it's also just the Brown ethos. It is in the drinking water. On campus, you can sense the strong value for and sense of urgency about solving social problems."

These same values of interdisciplinary study and the promotion of social well-being have formed the backbone of the Institute since its inception in 2014. According to many, its synergy with the larger Brown culture is part of what makes it so unique, as a unit.

"I like the IBES program specifically because it's 'very Brown' in terms of its structure; that is to say that there is a deep focus on the analytical piece of it, the changes," says Warren Kanders, IBES Advisory Councilor and Executive Chairman of the Board of Black Diamond, Inc., a manufacturer and distributor of technical outdoor and active lifestyle products. "It's not where you are, it's where you're going, and what the world's going to look like 10, 20, 50 years from now. You need to plan, and organize, and predict. And I think that the program as it currently stands really helps people understand what the impact is on various things that we're doing today, and how that can influence the future in a quantitative way as well as in a social way."

"To have a program like IBES—which values, emphasizes, and demands fluency from its students, whether undergraduate or graduate, across multiple disciplines—is really critical," adds Kathryn Fuller, Chair of the IBES Advisory Council and Vice Chair of the Smithsonian's Museum of Natural History. "The work is not only academically rigorous, but also has a great deal of applied relevance. Of course, Brown is a place where the students and the faculty are characterized by coloring outside the lines. And that, I think, is really critical if we individually and collectively are going to have a positive impact to mitigate forces that are undermining the healthy


Advisory Council Chair
Kathryn Fuller


Advisory Councilor
Warren Kanders


Advisory Councilor
Bina Venkataraman

environment on which all creatures, including humans, depend."

One of the ways that IBES faculty and students 'color outside the lines' is by moving beyond academia to find solutions that are not only backed by research, but are also truly applicable to real world challenges.

"There's knowledge that comes from communities, and knowledge that comes from more traditional knowledge centers," explains Venkataraman. "Bridging them offers us the potential to do what hasn't been done before, to make progress that has never made before, to unleash insights that have never been unleashed before. This means bringing together experts from the academy and from outside the academy—who can tell us about how decisions are made and how communities use information."

"I think that's really become more urgent than ever with global climate change," she adds, "for academics and scientists to really listen to the knowledge that resides in communities and to use that knowledge to actually further the efforts of research and action."

Kanders and Fuller also speak to the necessity of understanding social and political forces when addressing environmental and sustainability challenges, as well as the importance of working effectively with the for-profit sector.

"Everything is tied to everything else," says Fuller. "The job is never done because social circumstances change, economic circumstances change, political circumstances change, the ecological pressures change, and you need to be prepared to engage and follow-up. It's an iterative and never-ending challenge."

The Institute is well positioned to tackle this challenge, with its aim to educate and engage future environmental leaders in a way that both brings insight to today's environmental problems and forges a new paradigm for solving tomorrow's.

"If we're going to have leaders in whatever walk of life they need to understand the world, writ large," Fuller adds. "Expertise, of course, is hugely valuable; but to understand the context in which you're operating is really critical."

Kanders agrees. "I don't think that we have enough folks that are educated in the sciences and who truly understand environmental issues and a whole host of issues working in our government," he says. "So as it relates specifically to public policy, I would hope that this [IBES] program also could interest some of the students to make a career in public policy and in government so that we have knowledgeable people making knowledgeable decisions."

"Brown is constantly training the next generation of leaders," adds Venkataraman. "It's really important that every generation of leaders is steeped in rigorous knowledge and the ability to think critically, but also that they embody the values of public service. And I think that that's something that Brown does especially well."

The Institute shares this view, preparing the environmental leaders of tomorrow by pairing innovative research with a rigorous course of interdisciplinary study. In this way, the Institute's current scholars and future alumni are poised to make a true impact on the world's most vulnerable populations and ecosystems, at a time when these issues have taken on new immediacy and global relevance.

"No matter what political or economic perspective you bring to the world, it's undeniable that all living creatures depend upon a healthy environment," says Fuller. "We, as humans, have not only unparalleled capacity to affect the environment—and, in many cases, not positively—but the responsibility to understand the implications of our actions."

"We want, in a very complicated world, to promote as much well-being for as many creatures large and small as we can," she continues. "And not simply because nature is beautiful, complex, and wonderful, but because it's also essential."

INTRODUCING: BRIAN LANDER

Brian Lander, formerly a Ziff Environmental Fellow at Harvard University, joins the ranks of IBES fellows this fall as Assistant Professor of History.

Lander, an environmental historian, specializes in examining the millennia-long degradation of Chinese ecosystems—specifically, the conversion of lowland environments into farmland. His research examines this transformation through a variety of historical lenses: political, ideological, economic, cultural, and more.

"I chose to focus on China," he explains, "both because humans have transformed its environment more than anywhere else on Earth, and because that process is recorded in unprecedented detail in 3000 years of documents."

This extensive written record allows Lander to revise common assumptions about the longevity of China's concerns over pollution.

"Discussions on how to deal with environmental problems are usually based on unspoken assumptions about what the 'natural' environment was in some poorly defined ideal past," he says. "But by looking at human impact on the environment over millennia it becomes clear that environmental problems are not new. The growth of human civilization has been based on destroying the habitat of other species, so any attempt to solve our environmental problems requires us to think hard about what our civilization is and what it could be."

Lander believes that the Institute is the perfect place both to continue his research and to collaborate with others investigating related concerns pertaining to environmental sustainability.

"A long-term historical perspective suggests that solar panels and organic farming cannot save the Earth unless they're combined with more profound changes to our social, political and economic systems," he says. "An interdisciplinary center devoted to the environment is the ideal place to think through these questions."

DIGGING FOR CLIMATE CLUES: ANCIENT SEDIMENTS HINT AT A WETTER FUTURE

The sprawling volcanic islands of Indonesia are famed for their lush, tropical flora; but during the last ice age, the region's rainforests were instead dry savannas where it rained only half as much as it does today.

Associate Professor of Earth, Environmental and Planetary Sciences **Jim Russell** and his team have pieced together this story by analyzing ancient sediments gathered from the depths of Lake Towuti, a yawning tectonic basin in South Sulawesi. Their findings reveal much about the region's climate history—and, potentially, about our planet's climate future.

LOCATION, LOCATION, LOCATION

The Indonesian archipelago sits squarely in the Western Pacific Warm Pool, an area of warmer-than-average water with an outsized influence on the global climate cycle. The El Niño Southern Oscillation emerges directly from this region, as does a large fraction of the atmosphere's stock of water vapor. That water vapor ultimately falls as precipitation—not just in the western Pacific, but all over the globe. And, it contributes to global climate change.

"Atmospheric water vapor is the most important greenhouse gas, not CO2," explains Russell. "Most of the greenhouse effect is water, and most water vapor comes from the western Pacific."

These relationships are thought to have remained relatively consistent over time, which makes Indonesia an attractive place to probe the geologic record for clues to past climate shifts. Lake Towuti alone is thought to hold somewhere around one million years worth of climate data, thanks to its dependence on the movement of Earth's tectonic plates. Indeed, both the lake and the sediment deposits underneath it are far deeper than the glacially-formed basins found closer to Brown.

"A glacier erodes out a hole in the ground and then leaves, and that's as deep as that hole will ever be," explains Russell. "But in a tectonically developing basin, the bottom will keep dropping until the tectonic motion ceases, which is typically timescales of millions to tens of millions of years. So these are systems in which you can get really, really long records of climate."

SECRETS IN SEDIMENT

The team's most recent drilling expedition exhumed about a kilometer's worth of sediment, and analysis is well underway.

The sediment deposits underneath beautiful Lake Towuti may hold up to a million years of climate data. Photo: Jim Russell

"One of the beauties of sediments is that they hold an array of different clues of climate and environmental change because they're composed of very, very diverse materials," says Russell. "They contain mineral matter that's washed in from soils, they contain pollen grains that are blown in from the vegetation around the lake, and there are various kinds of elemental and isotopic measurements that we can make on the sediments to extract climate information."

His lab focuses mainly on reconstructing two different aspects of climate from the sediment core they extracted: temperature, and rainfall.

In order to reconstruct temperature, the team relies on leftover chemical signals from ancient organisms buried in the sediment. Russell and his colleagues extract organic material from their samples, identify specific organic compounds called biomarkers, and measure different properties of these compounds in order to determine what climatic conditions were like at the time these organisms were alive.

One of the biomarkers that the team looks for are lipids: intercellular relics of ancient microbes and animals that thrived in the lake. "A lot of organisms will very slightly alter the structure of their lipids in response to changing temperature," explains Russell. "If a bottle of olive oil gets too cold, it condenses. Organisms can't allow their lipids to condense, so they vary the lipid structures."

He continues, "We can actually measure very small structural changes in cell membrane lipids, understand how they vary in relation to temperature, and then apply that to sediment samples to constrain temperature in the past."

The team also examines organic matter for the isotopes of different elements, and especially those of water. This process helps Russell and his colleagues to reconstruct the relative amount of rainfall seen at Lake Towuti, largely due to the presence of two different types of hydrogen.

Precipitation rich in heavy hydrogen, or deuterium, always falls from a cloud first. But when rainfall is high, lighter hydrogen is forced out of the clouds, changing the ratio between the two types. Organisms like trees then incorporate both kinds of atoms into their own structure, preserving the ratio for scientists like Russell to uncover.

"By measuring isotopic composition of the leaves," he explains, "we're actually measuring the chemistry of rain, which varies in response to just how much rain is falling."

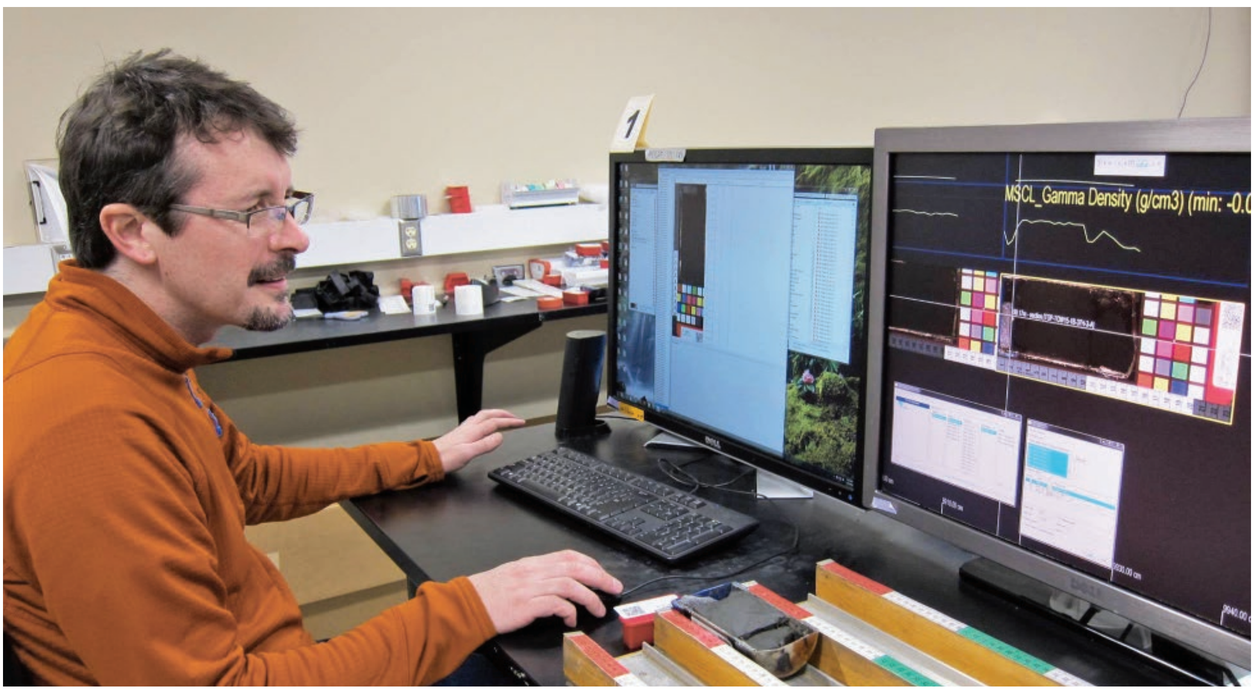
AN UNCERTAIN FUTURE

The team's analysis suggests that, during the last ice age, Lake Towuti and the surrounding area was far drier than it is today. Over the next 10,000 years, as the planet moved into an interglacial period, the climate transitioned from dry to wet—in lockstep with atmospheric CO2 levels. This discovery provides an opportunity for scientists to compare past changes in climate with those that we are witnessing today.

"Since the industrial revolution, the amount of CO2 in the Earth's atmosphere has risen by about 120 parts per million (ppm)," says Russell. "And during the last glacial to interglacial transition, between 20,000 and 10,000 years ago, greenhouse gas concentrations rose by about 100 ppm. So it's about the same change."

"The big difference, of course, is how fast it happened," he continues. "It was a much slower process during previous ice age transitions. The main reason that's important is that, at present, we know we haven't seen the full effects of that greenhouse gas emission change."

If the past is any indication, suggests Russell, rainfall in Indonesia is going to increase once again, in conjunction with global greenhouse gas emissions. Indeed, downtown Jakarta now floods almost annually. It is difficult to know whether these events are directly due to climate change, since scientists don't have long-term records of rainfall in the region the same way they do in other areas; however, it is likely that overall rainfall will increase, much in the same way as it did



Jim Russell describes and logs Towuti sediment cores at the National Lacustrine Core Repository, University of Minnesota.
Photo: Kristian Brady, University of Minnesota

Jan Thorsten Blanke (Leibniz Institute of Applied Geophysics) prepares the drilling rig to log the geophysical properties of the borehole. This technique allows project scientists to recover physical and chemical information about the sediments in situ in the lake floor. Photo: Jim Russell

between the last ice age and today. Scientists just don't yet know by how much.

The ambiguities in this forecast could spell trouble for the local economy. "Indonesia is a developing country," explains Russell. "The country subsists on rice and other crops that are grown expecting a certain amount of rainfall to come at a certain time. And as we look into the future, there is huge uncertainty in how rainfall patterns are going to vary in that region."

There is also considerable uncertainty surrounding how changes in climate will affect endemic species in the decades ahead. Collaborations are underway with scientists from other disciplines—for example, Institute conservation biologist Dov Sax and paleoecologist Sarah Ivory—to broaden the reach of the team's paleoclimate data into other fields.

To this end, Russell and his colleagues plan to continue examining the sediments drawn from Lake Towuti for many years ahead, painstakingly moving backward in time to determine whether the climatic patterns they have uncovered hold true for previous ice ages as well.

"Each one of these glacial-interglacial transitions represents kind of a climate experiment in which temperature and rainfall changed," he says. "And we can ask, 'how do ecosystems sense that?'"

Paleoclimate data from the depths of Lake Towuti has the potential to answer this and a wide variety of other questions, not only about local ecology, but about agriculture, social concerns, and global climate in the decades ahead. In this way, Russell hopes that the past will help to inform the future.

Thanks to the surprisingly wide variety of signals that can be extracted from sediment, the team has many ways to make that happen. "Ultimately, I want to contribute a better fundamental understanding of how tropical rainfall changes and why," he says, "But there's a lot we can do to use the paleoclimate records to understand impacts on ecosystems and society." ■

STUDENTS DISCOVER LOCAL ENGAGEMENT, GLOBAL VIEW

IBES course facilitates community partnership and interdisciplinary study

Dawn King's *Humans, Nature, and the Environment: Addressing Environmental Change in the 21st Century* attracts a potpourri of undergraduates. More colloquially known as "ES 11," the course draws Brunonians of all class years and from a variety of disciplines, each seeking a way to learn more about the field of environmental studies while simultaneously becoming more involved in the local community. The time- and labor-intensive course is cross-listed in the University's Engaged Scholars Program; and as King explains, the categorization is well-earned.

"It's probably one of the most engaged courses at the University," she says. "All of the [students' assignments], for the most part, have an engaged option. Even the final paper and or project can involve working with a community partner."

These community partners take many forms; in recent years, students have paired up with local farms, non-profits, advocacy groups, and city offices to contribute in ways that are customized to the real-world needs of the organization—whether that means digging into archives, mapping the state's "blue economy" with GIS technology, building a portable chicken coop, or convincing Brown's dining office to partner with fishermen in order to offer more sustainable dietary options.

And although students learn plenty from their partnerships, in many ways community groups are the real beneficiaries.

"When Dawn King's students are done, the community benefits," says

The ES 11 team, from left to right: Allyson Masunaga Goto, Thomas Culver, Lauren Maunus, Lecturer Dawn King, Kaori Nagase, Logan Dreher, Brendan George

Julius Kolawole, President of the African Alliance of RI, a long-time partner to King's students. "Whatever they do, the community gets benefits. That aspect of what they do is what I refer to as the 'community practice'. In other words, they leave something behind."

"College can be such an insular experience," adds Tess Brown-Lavoie of Sidewalk Ends Farm, another local organization that has hosted many ES11 students over the years. "There is so much going on on campus and in classrooms to captivate a student's mind and time, but we consistently hear that trips out to the farm help initiate valuable relationships with the greater Providence community."

This sentiment is echoed by many of King's former students, especially those who currently act as Teaching Assistants for the class.

"Brown, in so many ways, can act really siloed from the rest of Providence and the rest of Rhode Island," says Thomas Culver '17. "But these engaged projects really force a part of the Brown community to engage with part of the community outside and form meaningful long-term connections."

"I think that this class does a really successful job at making students think about their role in the community," adds Allyson Masunaga Goto '18. "How they can help in a really meaningful way that isn't just surface-level stuff, and that really gets to the deep roots of the problems that we talk about in class."

Although the course itself is designed to be introductory, its immense breadth encourages non-concentrators to cultivate deep-rooted environmental perspectives, and to make connections within their own disciplines.

"It is a survey class, but you hit on different angles," explains Kaori Nagase '17. "You get a little bit of electoral politics or a little bit of science or a little bit of econ. And even if you don't end up concentrating in Environmental Studies or Science, many students take classes in those respective departments, or choose to explore environmental issues through class assignments, papers, and projects."

Moreover, the course encourages students who do concentrate in ES to consider environmental issues from a socio-political perspective.

continued on next page

postdoc spotlight

Out of the many environmentally-focused economies in the world, two seem to stand out: Costa Rica, for its forest conservation, and Cuba, for its sustainable agriculture. But how accurate are these perceptions?

Dana Graef, an environmental anthropologist and joint postdoc between the Institute, department of Anthropology, and the Cogut Center for the Humanities, is holding a critical lens to the apparent exceptionalism of these two countries and asking, "What does it really mean to be 'green'?"

Graef explains that, in reality, both Costa Rica and Cuba have robust sustainable agriculture programs and conservation efforts; in her view, the seeming distinctions between the two are influenced by their different political and economic conditions.

"One of the things that I found is that, in these different countries, people tend to relate political rhetoric to the landscape—whatever landscape that is," she says.

"The focus on forest conservation in Costa Rica supports Costa Rica's national reputation for being a peaceful, democratic nation," she continues. "People see alliances between forests and stability and democracy. Whereas in Cuba, the effort and labor of sustainable agriculture contribute to the national reputation of a country that opposes global capitalism."

Through her research, Graef wants to understand more about why people all over the world draw these parallels; but she also wants to bring to light perspectives from Costa Ricans and Cubans themselves.

"Citizens of these respective countries also have their own preexisting environmental ideologies," she explains. "Environmentalism is not something that comes from the global North, that comes from the U.S. or Europe, and is brought to people in Latin America. I want to emphasize that Latin American environmentalisms are also really important and valuable."

Global View, continued

"I always thought I was really interested in the politics behind international relations and diplomacy, and I thought the environment was totally separate from that," says Lauren Maunus '19, who decided to concentrate in Environmental Studies after taking King's course. "Coming into ES 11, that was the first time I made the connection that the environment is the most fundamentally global issue."

"There are some courses at Brown that teach you how to think—and not only make you think about problems, but change how you think about thinking about those problems," adds Brendan George '18. "This for me is one of those classes. It teaches you that there is no one environmental framework and that these issues are so interdisciplinary. If we're talking about water issues or transportation issues, there's no way you can leave out energy issues and food issues. These things all interact with each other."

"And then add on the fact that you have everyone in the classroom who's coming from a different angle and a different concentration and background," he continues. "It's just an eye-opening class. I think it opens people's minds."

The TAs are careful to note that ES 11 would not be what it is today without King's influence.

"While she makes it so accessible and so interesting, she also really centers the intersections of race and class and gender in the environment," says Logan Dreher '19. "That's not something that other environmental teachers always do. She really presents it in this political and social dimension."

Students who act as TAs for ES 11 do so out of profound gratitude and respect for the experiences they had as students in the class. For many, the course shaped not only their academic trajectory, but also their relationships to the world outside the University.

"It really helped all of us navigate our time both here at Brown and in the greater Providence community," concludes Masunaga Goto. "It has truly helped define my college experience, and I think that's something that this class offers that isn't true of all courses. It's empowering, and that's why it's so unique." ■

student spotlight

When **Maaike Tiersma '17** and **Ellyn Vitek '17** signed up for an internship with the Nature Conservancy, they knew next to nothing about sustainable aquaculture. But now all of that has changed, thanks to one summer spent exploring the effects of newly-built oyster reefs on the health of local waterways.

"There's an overall trend moving toward reestablishing Rhode Island as an oyster economy," says Tiersma. "It was a really, really big industry in the early 1900s that was wiped out because of [human action], but now we're trying to get it back."

In order to accomplish this goal, conservation workers have taken to local ponds and waterways, where they stack oyster shells on top of one another to form reefs. Lab-grown oyster larvae then bind to the shells, mature, and recruit other oysters to join the growing reef. This process is designed to enlarge the local population of oysters, whose filter-feeding behavior will ultimately improve the health of other marine organisms that call the waterway home.

Tiersma and Vitek spent months assessing the effect the reefs had on local ponds. And after spending long days on the water capturing, categorizing, and counting the resident fish and crustacean species, both students came away from the experience with a renewed respect for and interest in fieldwork.

"People can make all the predictions and estimates of what's going to happen to an environment that they want, but you don't actually know what's happening until you actually get out there and you test species and water samples and soil and actually see the environment and compare it to past studies," says Vitek. "You can look on a computer and say, 'this is probably going to happen', but you don't actually know that for sure until you get out there. That's the whole point of fieldwork, is that you see for yourself."

EXPLORING HAZARDOUS LEGACIES

Old industrial sites lend a new view of cities

The point of this project is to try to understand how the natural and the social are really inextricably intertwined. You can't tell the story of cities without talking about ecology, and vice versa.

Mashapaug Pond, in southwest Providence, was once the site of a bustling industrial plant called the Gorham Manufacturing Company. From the late-19th century until the middle of the 21st, the Gorham factory churned out some of the country's finest silverware and bronze casts, all the while pumping large quantities of effluent into the soil and water. In recent years, the Rhode Island Department of Environmental Management has worked with current property owners and the city of Providence to remediate the site of the old factory, which now hosts a high school; however, the pond itself and some of the surrounding land remain contaminated, including areas close to residential neighborhoods.

Professor of Sociology **Scott Frickel** knows that this story is not unique. Across Rhode Island, his study has identified more than 11,000 industrial sites that have operated since the 1950s. Most of those old industrial sites are located in the Providence metropolitan area and many are used for other, non-industrial activities today. But an unknowable number of these sites are likely to contain legacy hazards from earlier industrial activities.

By mapping these relict industrial sites in both space and time, Frickel and his team aim to better describe the societal impacts of the sites' hazardous legacies. Thus far, their research has revealed a surprising fact: the presence of industrial activities—and whatever environmental contaminants those activities may leave behind—are more widespread in cities than had been previously thought.

"What we're finding out is that environmental risk is cumulative," he says. "Over time the accumulation of relict industrial sites from block to block, neighborhood to neighborhood, can become a problem for most people who live in cities."

"More broadly, we can also begin to theorize about cities as socioenvironmental processes," he says. "That's the theory that we're trying to build with this project:

student spotlight

It all started in Dawn King's engaged scholarship course, Urban Agriculture, during which **Louis Epstein '19** recalls writing his first food security report: a literature review and community engagement project for the city of Central Falls, Rhode Island. The following summer, he brought those skills to Bogotá, Colombia, where he worked for law advocacy organization Asociación Ambiente y Sociedad, examining the state of food security in the capital and other major cities.

Epstein explains that, despite the existence of many treaties guaranteeing food security, Colombia's people do not always have enough to eat.

"I basically did an analysis of some notable government food programs, and if they worked," he says. "I also analyzed and interviewed some people who were working outside the government framework: campesinos, or people who work in the fields—who have their own organizations that do food, kind of direct-to-market."

Epstein found that government allowances such as the country's school lunch program often did not provide recipients with nearly enough food; however, smaller, grassroots movements on the part of campesinos and other villagers held promise.

"Some of the campesino movements had pretty effective ways to get food to the city," he says. "But again, they're really small. I think with government help they could be a lot better."

Epstein, whose mother immigrated to the United States from Colombia in the 1980s, has always dreamed of visiting Bogotá. He explains that he is grateful to have been able to take advantage of the Institute's internship opportunities abroad, and to do some good in the process.

"The grants [offered by the Institute] are unbelievably kind," he concludes. "The financial aid waiver from IBES was also spectacular, because I could not have found that money otherwise. So—thanks, IBES. Louis says, 'thanks.'"

trying to understand the way in which ecosystems and urban social systems are mutually shaping one another all the time, continuously, to create these places that we call cities."

Frickel stresses that the regulatory environment often reviews relic industrial sites individually, rather than taking into account the dynamism of entire regions over time. But in the watershed surrounding the old Gorham plant alone, graduate students Thomas Marlow and Michael Murphy have compiled a database of 122 unique sites that, since the 1950s, have been likely sources of legacy contaminants.

"That's a whole different way of telling the environmental history of that place. It's not just about that one factory," says Frickel. "I wouldn't want to minimize the significance of the Gorham plant for doing damage to the environment and to public health risk, but that's not the whole story. And I'm interested in scaling up our ability to understand these sorts of interactions."

Historically, industrial activities have been imperative to the proliferation and success of cities; but from Frickel's perspective, the impact these activities have had on the natural environment, which is an equally vital requirement for societal growth, is far less appreciated.

"You could argue that what we're really telling a story of is a story of economic success. This is how cities grow and develop and produce money and jobs," he says. "But the flip side of that is that these activities fundamentally degrade the ecosystems that cities also require."

As Frickel explains, industrial contaminants contribute directly to the devaluation of limited and precious urban land. This has consequences not only for the natural environment, but for groups of people who ultimately hope to use that land in other ways, decades or even centuries down the line.

"The point of this project is to try to understand how the natural and the social are really inextricably intertwined," he says. "You can't tell the story of cities without talking about ecology, and vice versa."

"When we think about cities, we often think about them as social creations," he continues. "Nature is usually missing. And so we're trying to correct that."

This year his team plans to develop an interactive public website as a way to bring the historical dynamics of the Providence's industrial past to a larger audience.

THE ECONOMICS OF NATURAL DISASTERS

Storms and risk impact economic growth in important ways

Each year, hurricanes and tropical cyclones pose a looming threat to countries all over the world—not only for fear of life and limb, but also for their catastrophic effects on regional economies. Assistant Professor of Economics **Lint Barrage** studies the consequences of such disasters through a macroeconomic lens, with a goal of determining how economists can best conceptualize the risk these storms pose for different nations.

Historically, many similar studies have published conflicting results. Some have found that natural disasters enhance economic growth, while others have found that they depress it. Barrage and her colleague, University of Arizona economist Laura Bakkensen, have highlighted one particular source of this conflict: the economic consequences of storm strikes differ from those that occur when there is a perceived *risk* of such strikes.

According to Barrage and colleagues, the Philippines is one of the most severely cyclone-impacted countries in the world. The nation faces a very large negative impact on both growth and welfare, despite increased savings rates among its people. Photo: kuroboshi

As Barrage explains, when a hurricane or tropical cyclone strikes, countries often must divert large amounts of otherwise productive money toward rebuilding losses and repairing damages. These costs can take a significant toll on afflicted economies in the short run, and may never be fully recovered.

Conversely, when people believe that they are at risk for experiencing a natural disaster, they generally invest more in safer ventures such

continued on next page

Natural Disasters, continued

as human capital and education, helping economies grow. At the same time, citizens may also become less likely to invest in high-return but risky ventures, such as small-scale businesses that cannot insure against cyclone risks. On net, however, Barrage and her colleague find that the threat of cyclone risk typically increases savings and investments to the point where it drives economic growth upwards in the long run.

However, as Barrage notes, although "economic growth" tends to be a positive buzzword, it is not always an accurate barometer for the well-being of a nation's people.

"If people are scared because they face a larger risk from natural disasters, they may save more and that may increase growth—but they're not better off," she says. "They're just guarding themselves more against risk."

Barrage and her colleague have found similar macroeconomic effects across 190 countries, based upon data logging storm strikes and storm risk over the last 60 years. She is careful to note, however, that developing countries are still hit far harder by both risks and strikes than are developed nations.

"One of the things that makes natural disasters much more damaging for developing countries is the fact that they don't have as well-developed of a financial market as the U.S.,"

If people are scared because they face a larger risk from natural disasters, they may save more and that may increase growth, but they're not better off. They're just guarding themselves more against risk.

Barrage explains. "In the U.S., there's insurance, you can hedge on financial markets, the government implicitly insures people through FEMA, and things like that. Even if your house is affected by a natural disaster, that doesn't necessarily mean you lose everything."

"In poor countries, those kinds of mechanisms are a lot less available," she continues. "For people to avoid being truly wiped out by a natural disaster, they have to take more precautionary measures and protect themselves more on their own against these disasters."

Barrage explains that even small disasters can have a whopping impact over time, especially in the most vulnerable areas of the world: "Every year that you're missing out on even just a tenth of a percentage point of economic growth—over time, that adds up to huge amount of wealth that's permanently missing from countries that could be better off if they could deal better with natural disasters."

Understanding the subtle differences between the economic effects of perceived storm risk and those of true storm strikes will not only promote the financial well-being of a nation's people, but also serve to protect them effectively in a world where severe weather events are becoming more frequent and more intense.

As Barrage explains, one key way to ensure that natural disaster policies are both effective and sustainable is to base them on sound macroeconomic analysis.

"The most important insight," she says, "is that the mechanisms through which natural processes affect the economy really matter." ■

INTRODUCING: TYLER KARTZINEL

Nature is full of surprising interactions between species. Whether it's by working together, avoiding each other, competing with one another, or making a meal out of one another, species are connected in a variety of ways. **Tyler Kartzinel,** conservation biologist and one of the newest IBES fellows, knows that understanding these interactions and their vulnerabilities is the key to effective conservation. His overarching goal is to use methods from both field ecology and genomics to understand who interacts with whom in nature, and why it matters.

As Kartzinel explains, scientists often know surprisingly little about the ecosystems they aim to protect.

"In the African savannas that I study, it can be incredibly challenging to figure out what animals are eating," he says. "My research is both reaffirming much of what we thought we knew, while also revealing little surprises in the diets of charismatic species like elephants, giraffes, and zebras—not to mention the smaller mice, gerbils, and shrews."

Kartzinel has carefully crafted his research to yield ecological insights that are as interesting as they are useful.

"Ecology is such an exciting field. Amazing discoveries are made all the time," he explains. "The challenge, as conservation biologists, is to make sure we're asking the right questions—the questions that help protect the environment and improve people's lives in the real world."

From his perspective, the Institute is a perfect place to conduct such work.

"I think IBES provides a unique opportunity to focus on seriously cutting-edge science without losing sight of the bigger picture," he says. "The collective knowledge and collaborative spirit of the IBES faculty and students makes our community exceptional. I'm thrilled to be a part of it."

graduate student spotlight

Scientists know that industrial contaminants pose a danger to aquatic life; what they do not yet know is whether other additives that are often present in waterways help or hinder this problem. Here at IBES, former graduate affiliate **April Rodd** is using a test case of two materials—carbon nanoparticles and benzo(a)pyrene—to explore the effects of such chemical mixtures on fish.

Rodd, who earned her PhD in early 2017, employs a new form of technology called three-dimensional cell culture to study fish liver cells. In this process, scientists modify the more classic, single-layer culture and turn it into something more closely resembling the cells of a living organism.

"Instead of having a flat, single layer of cells, you force it to assemble into a ball of tissue instead," she explains.

Rodd and her colleagues are familiar with the toxic effect of benzo(a)pyrene, a polycyclic aromatic hydrocarbon (PAH) commonly found in oil spills, on cultured fish cells alone—but the combined effect of this chemical along with other, emerging compounds, such as carbon nanoparticles, is unclear.

"I'm hoping to get some basic answers on that, as well as to get into this idea of what makes a nanoparticle toxic," she says. "Is it shape? Is it functionalization? What is it about a particle that makes it have a protective effect—where there is reduced toxicity associated with the particle—or a synergistic effect—where perhaps it enhances uptake?"

Rodd hopes that her work will inspire other researchers to begin examining the links between the various chemical compounds that threaten aquatic ecosystems.

"Even if we stopped using petroleum products today, we still have lots of leaching sources of PAHs in things already in our environment," she says. "This work is a case study for the interaction between a new and emerging contaminant, carbon nanomaterials, and something that already exists in our waterways waiting to interact with it. And that's really important."

THE PHYSICS OF CLIMATE

Building a bridge between climate and theory

For many, the title *theoretical physicist* conjures images of wild-haired scholars poring over complex equations in an effort to solve esoteric scientific problems. But **Brad Marston**, Professor of Physics, is not wild-haired. And the problem he seeks to tackle is far more down-to-Earth than those stereotypes would lead one to believe. He wants to bring ideas from theoretical physics to the realm of environmental science—a bridge that he hopes will enable scientists to better understand the climate system and predict the changes that are headed our way.

Marston explains that the climate system lends itself well to study within the framework of a branch of his discipline called statistical physics.

"Basically, climate is the statistics of the weather. And in statistical physics, which is a big area of physics, we try to find the statistics of whatever we're studying—like a gas—directly, without trying to model the motion of all the individual molecules," he says. "The hope is that similar thinking can lead to a better understanding of the climate system, and also maybe a more efficient or more accurate simulation of the components of the climate system."

One of the ways that climate phenomena are different from other statistical systems, however, is that they have intrinsic structure; that is, the random and uniformly chaotic movement that characterizes molecules of a gas in statistical physics is at odds with the comparatively organized arrangement found in climate features such as clouds, or the jet stream.

But despite this difference, Marston believes that he is able to identify ways to describe these elements in physical terms by looking for similarities between their structures and other, better-understood physical phenomena.

"Once we recognize these structures," he says, "then there's some underlying simplicity that can be exploited."

This is not Marston's first foray into physical pattern-seeking. He describes the moment when he realized that his postdoctoral work on atomic scattering bore a striking mathematical similarity to his seemingly unrelated, more recent work: modeling flows in the atmosphere and oceans.

"In physics, there's often a recapitulation of the same themes," explains Marston. "They reappear in different areas, and it's kind of surprising somehow that that happens. It just seems that the natural world is well-suited, or at least some elements of it, to a mathematical description, and sometimes the same mathematical description appears [over and over again]."

Marston is currently chair of the American Physical Society's Topical Group on the Physics of Climate, a relatively new unit that he hopes will encourage more physicists to start working on the problem of climate change.

"I think it's the number one problem facing humanity," he says. "We don't have any viable path right now to stabilizing the climate, and I don't think people realize how bad things might get."

Marston is hopeful that a more physically rigorous understanding of climate phenomena will strengthen climate models and enable scientists to make more accurate predictions of climate change—especially at the regional level, where uncertainties abound.

"That's a long-term project," he says. "And maybe all the climate change will occur before we actually are able to predict it."

He laughs ruefully. "But we try to do what we can." ■

graduate student spotlight

Australia's Murray-Darling Basin is a landscape alternately parched by drought and deluged by floods. In this highly variable climate, graduate affiliate **Zac Bischoff-Mattson** wants to understand how the region's people make decisions about water—a resource whose social and political worth is only destined to become more complex on a rapidly warming planet.

Bischoff-Mattson's research centers around a framework called adaptive governance—a form of decision-making that seeks to customize goal-setting with respect to local perspectives, norms, and power dynamics.

"We need an adaptive, and above all contextual, process for identifying common interests, and for bringing different knowledge systems to bear in advancing those common interests," he explains. "This is ultimately about a reflexive process for social learning… and approaching a system where everything, including our own goals and the values at stake, are a moving target."

The Murray-Darling Basin is especially well-suited to Bischoff-Mattson's exploration of adaptive governance principles, in part because of its diversity.

"This is an area with urban and rural populations," he says. "It's the agricultural heartland of Australia and is really responsible for the majority of its agricultural domestic product. It's also a place where there are indigenous communities that have a living connection to country stretching back 40,000 years."

Ultimately, Bischoff-Mattson hopes to contribute to the conversation on water rights in Australia and the ways in which current management strategies affect the lives of the region's diverse sets of people.

"The Murray Darling is really an iconic test case for dealing with this stuff, he says. "When it comes to variability and scarcity at a large scale, when it comes to addressing those complexities as well as the diversity of human values attached to water, the Australians are grappling with stuff that will define the challenge of water governance in a climate changing world."

INSTITUTE UNDERGRADUATES PROBE ENVIRONMENT AND INEQUALITY

Undergraduate concentrators now have a new way to delve deeper in Environmental Studies or Environmental Science: the **Environment and Inequality** track. This new option joins four other tracks currently offered by the Institute—Air, Climate, and Energy; Conservation Science and Policy; Land, Water, and Food Security; and Sustainability in Development—as a focused course of study that provides students with the opportunity to develop expertise in an environmental subject area.

So many environmental problems in the world link to inequalities. The poor and Historically Underrepresented Groups often bear the brunt of toxins, pollution, and environmental externalities while others profit from 'free pollution.'

The track, which was requested by students and formally developed by a committee comprising faculty members Timmons Roberts, Dawn King, Dov Sax and Bathsheba Demuth, as well as students Ximena Carranza '17 and Lauren Maunus '19, will be offered for the first time this Fall.

"The track is significant in that so many environmental problems in the world link to inequalities," says King. "The poor and Historically Underrepresented Groups often bear the brunt of toxins, pollution, and environmental externalities while others profit from 'free pollution.' Globally, women are more negatively affected by environmental toxins and disasters than men, and sometimes even the poor."

All concentrators who choose the EI track will take a specific course on the subject within IBES, and will also be required to take a course on race, gender, and/or income inequality without an environmental focus. Furthermore, students pursuing a Sc.B. will be required to concentrate more rigorously on a focal area within EI: Globalization and Development, Health and Inequality, or Environmental Inequalities in Food, Water, and Energy.

"The creation of a new track on Equity and Environment brings a crucial part of understanding the roots of our environmental issues, a window on who suffers and benefits from the distribution of 'goods' and 'bads,' and why that matters for solving these complex problems," concludes Roberts. "The new track builds on our existing strengths within IBES and across this very lively university. Concentrators will gain crucial insights and learn to put them into action." ■

MAKE A GIFT

Gifts to IBES are used to provide domestic and international research experiences for undergraduate and graduate students, prototype new research ideas, empower students to pursue learning opportunities, and more.

For more information on giving to IBES, please contact Meghan M. Frost at 401-863-1894 or Meghan_Frost@brown.edu.

LEADERSHIP

Director: Amanda Lynch, Earth, Environmental & Planetary Sciences
Deputy Director: Dov Sax, Ecology & Evolutionary Biology
Director of Graduate Studies: Scott Frickel, Sociology
Director of Undergraduate Studies: Dawn King, Environment and Society

INSTITUTE FELLOWS

Lint Barrage, Economics
Bathsheba Demuth, History
Meredith Hastings, Earth, Environmental & Planetary Sciences
Tyler Kartzinel, Ecology & Evolutionary Biology
James Kellner, Ecology & Evolutionary Biology
Brian Lander, History
Stephen Porder, Ecology & Evolutionary Biology
J. Timmons Roberts, Sociology
Leah VanWey, Sociology

TEACHING FELLOWS

Samiah Moustafa, Environment and Society
H. Curtis Spalding, Environment and Society
Kurt Teichert, Environmental Studies

ELECTED FELLOWS

Anna Aizer, Economics
Kim Boekelheide, Pathology
Joseph Braun, Epidemiology
Erika Edwards, Ecology & Evolutionary Biology
Andrew Foster, Economics
Baylor Fox-Kemper, Earth, Environmental & Planetary Sciences
Justine Hastings, Economics
Timothy Herbert, Earth, Environmental & Planetary Sciences
Yongsong Huang, Earth, Environmental & Planetary Sciences
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Karl Kelsey, Epidemiology
Jung-Eun Lee, Earth, Environmental & Planetary Sciences
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Back cover: Coastal vulnerability in island nation Kiribati. Photo: kuroboshi

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