EARTH MATTERS

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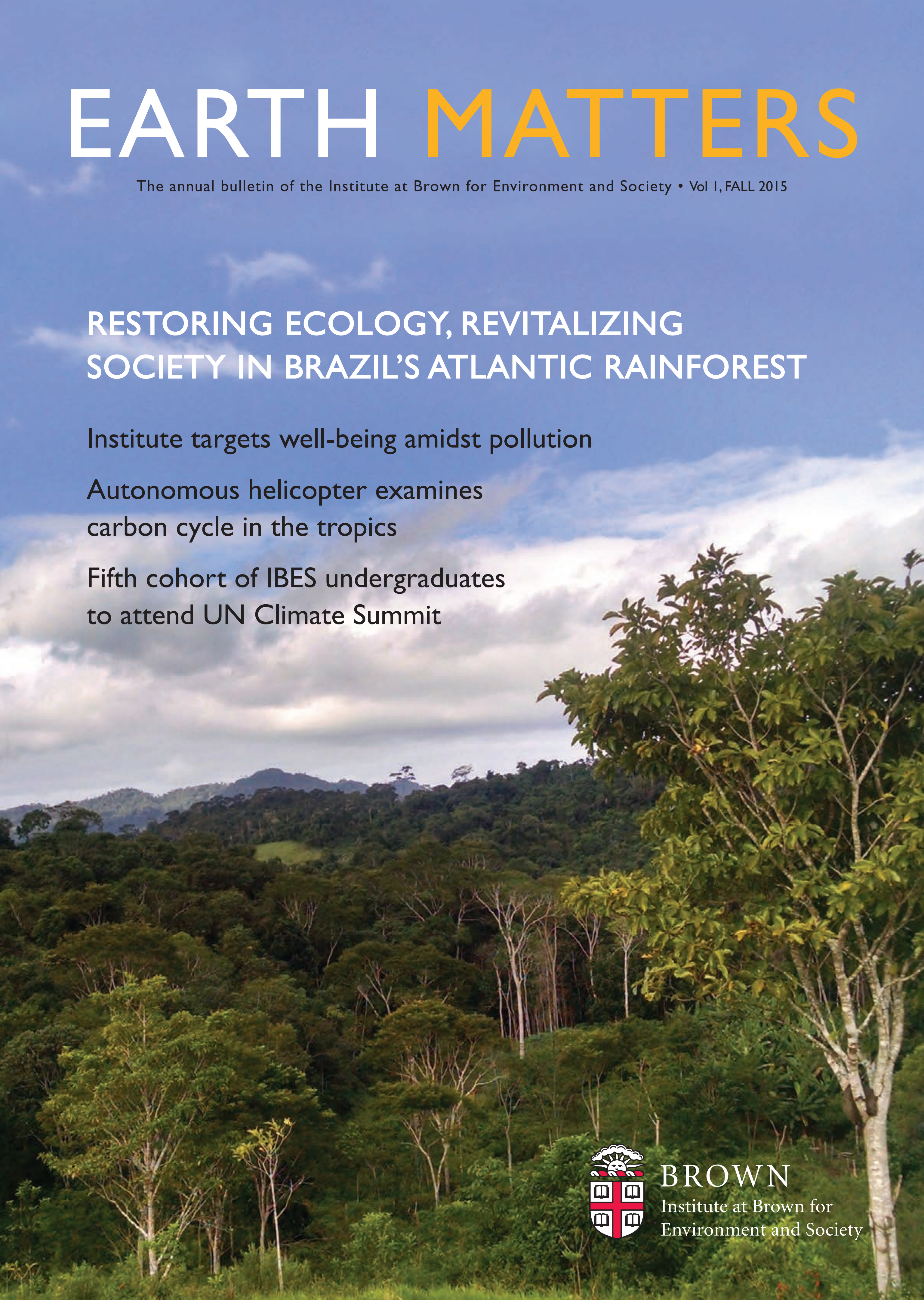
RESTORING ECOLOGY, REVITALIZING SOCIETY IN BRAZIL'S ATLANTIC RAINFOREST

Institute targets well-being amidst pollution

Autonomous helicopter examines carbon cycle in the tropics

Fifth cohort of IBES undergraduates to attend UN Climate Summit



BROWN
Institute at Brown for Environment and Society

LETTER FROM THE DIRECTOR

Water is the basis for the existence of life on Earth. Without its transport from the ocean surface to the continents in major atmospheric circulation systems and its release as rain and snow over the land, terrestrial flora and fauna would be without the water and food necessary for survival. But water is more than an essential chemical component of the earth system. Water is a source of conflict, a habitat, a human right, and a commodity.

Severe droughts and major floods have changed civilizations in recorded history and in the archaeological record. Significant increases in the number and severity of these events are already being observed in many places throughout the world. These increases have been rigorously attributed to emissions of greenhouse gases by human activities. But at the same time, we are placing more people and more assets in harm's way. At this moment, every continent of the world apart from Antarctica is experiencing these extremes. In Brazil, the city of Sao Paolo is relying on dwindling emergency water reserves as flash floods and mudflows impact northern Chile. In Africa, maize production is down by almost one third due to drought in the south as floods in the southeast have displaced hundreds of thousands of people.

It is estimated that at least 750 million people lack access to safe drinking water and many more lack access to adequate sanitation. In many countries around the world, people are forced to make undignified and unhealthy choices about water. Persistent shifts due to climate change and natural cycles such as El Niño add to problems of governance and infrastructure to create crisis and conflict.

We focus our efforts on the people and systems most at risk.

Water is one of several problems that sits at the nexus of environment and society. These problems challenge our knowledge systems, research paradigms and teaching goals. The Institute at Brown for Environment and Society has been established to advance human dignity and well-being, convening disciplinary experts to both advance fundamental understanding and solve real-world problems at this nexus.

We focus our efforts on the people and systems most at risk. Through research and education, we fortify the vulnerable with knowledge, supporting their informed choices to improve their lives and the environment that sustains them.

Where it matters most.

Amanda Lynch, Director

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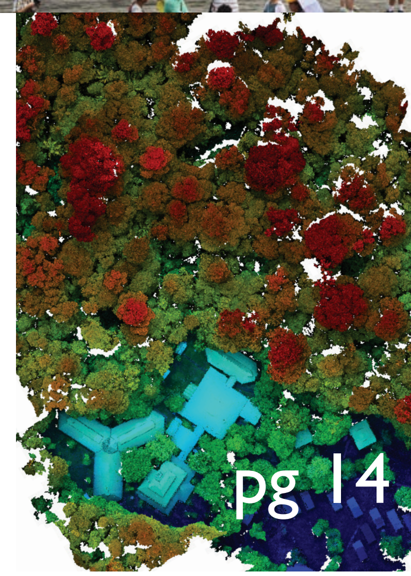


THEME COLOR CODE

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

RESTORING ECOLOGY AND REVITALIZING SOCIETY IN BRAZIL'S ATLANTIC RAINFOREST

To most ears, *tropical rainforest preservation* and *economic development* are diametrically opposed ideals; but to one team of natural and social scientists, the tensions between the two are fertile ground for innovation.

Lovinia Reynolds '17 and IBES postdoc Justin Becknell engage in an agroforestry experiment in which native trees are interspersed with cacao to provide habitat for wildlife and income for people. *Photo: Stephen Porder*

The story centers on a region of forested Brazilian coastline known as the Mata Atlântica, a 1000-mile long tropical rainforest that once teemed with spectacular biodiversity all the way from northern Brazil to Argentina.

Today, only about 10% of the original forest remains, a direct consequence of more than 500 years of logging, intensive agriculture, and population growth. Many plants and animals native to the forest are now on the brink of extinction. At the same time, small farmers in the Sul da Bahia, an economically poor region that is home to some of the largest remaining Mata Atlântica forest fragments, have few options for rural socioeconomic development; many of their children are abandoning the countryside for Brazil's megacities.

In an effort to save the Mata Atlântica biome, a multi-organization network has made a commitment to restore 15 million hectares of Atlantic Forest by 2050. This network has made some progress in creating protected areas and encouraging corporate landowners to plant large tracts of forest; however, no one has developed a similarly successful program for landscapes like the Sul da Bahia that are dominated by private landholders. In order to promote landscape-wide restoration, researchers must determine what measures are most likely to engage the residents of Bahia in local restoration efforts.

To this end, a group of natural and social scientists from the Institute, together with scholars from three Brazilian institutions, have launched an ambitious and novel five-year experiment: to understand the best way of restoring biodiversity to the rainforest while simultaneously promoting the social and economic development of the region's people.

NOT THE AMAZON

Unlike the famed Amazon, the destruction of Brazil's Mata Atlântica gets little press, yet the latter forest is by far the more imperiled. According to Daniel Piotto, a member of the research team who hails from the Federal University of the South of Bahia at Ilhéus (UFSB), "In [Mata Atlântica], most of the forest has been cut, so we're talking about 7–10% left. In the Amazon, we're talking about closer to 80–85% left."

"Atlantic forests have been disturbed for about 500 years, and the Amazon is just a brand new frontier," he continues. "The first road in the Amazon was back in the 70s, so we're talking about 50 years ago. It's a very different situation."

Thus the challenge in the Mata Atlântica is different from that in the Amazon; forest protection must go beyond preservation to restoration. Furthermore, such efforts can only succeed if they have clear benefits for the people who live where the forest used to be.

Institute scholars know that achieving both ecological recovery and socioeconomic prosperity will require an experiment on a scale never before undertaken in tropical restoration. Thus, the new research collaboration has two focal points: one in the social sciences, led by Associate Professor of Sociology Leah VanWey (IBES) and Rui Rocha, a social scientist at the Instituto Floresta Viva (IFV); and one in the natural sciences, led by Associate Professor of Ecology and Evolutionary Biology Stephen Porder (IBES) and aforementioned forest ecologist Daniel Piotto (UFSB).

Porder, Piotto, and colleagues will analyze the characteristics of both mature and regrowing (secondary) forests in order to determine the ecological consequences of various kinds of past land use. The results of their analysis will enable them to prescribe methods of forest restoration that are likely to be most successful.

Meanwhile, VanWey, Rocha, and fellow social scientists will work with 3000 households in Sul da Bahia to understand how they use their lands and how they earn their livelihoods. This information will ultimately help the researchers determine the economic incentives that are likely to both encourage forest restoration and produce the best societal outcomes.

Ultimately, these households will have the chance to participate in a payment program if they agree to restore forest on their lands. Unlike policies or subsidies that seek to prevent deforestation, those that encourage reforestation create landscapes that will pay farmers back in timber or forest credits in the future. The goal is to learn how different types of payments, and different restoration approaches, determine how much forest

Bahia, Brazil. *Photo: Jon Nelson*

grows back. It's a restoration experiment on an unprecedented scale.

"A SMALL LABORATORY"

The researchers' belief in the positive impact they can have on the region's environmental and societal welfare is clear; however, their focus on the Mata Atlântica is also quite calculated.

"Sul da Bahia is a place where we still have the last big fragment of the Atlantic forest, mixed with other forestry systems like small holders and forest plantations—very 'friendly' land use compared to monocultures of sugarcane or coffee," explains Piotto. "So in that sense it's a very strategic region, thinking about restoration."

If successful, the researchers believe that their efforts will have implications for regions far beyond the Mata Atlântica. Rocha calls the Sul da Bahia "a small laboratory," a reflection of the team's hope that its work in this region will prove applicable to other weakened ecosystems and communities along the length of the Atlantic rainforest and beyond.

Suggests Rocha, "[Our research] might apply in the Amazon and in Africa and Indonesia and the other regions where they have similar tropical conditions."

Extending their work to such faraway ecosystems will require training a new generation of natural and social scientists. Accordingly, the IBES-Brazil collaboration also includes a large educational component. Funding for the project, the result of an anonymous gift to Brown University, also supports two postdoctoral researchers and three Ph.D. students at Brown, at least four Brown undergraduates, three Brazilian M.S. students, and six Brazilian undergraduates.

This diversity in levels of expertise, Piotto explains, "is the heart of the project."

"[The students and postdocs] will be trained to design and to study things that are not just ecology or socioeconomics," he continues. "They will have a kind of multidisciplinary view of the problems."

Institute researchers know that this 'multidisciplinary view' is essential to addressing the persistent dilemmas that lie at the intersection of environment and society. Mata Atlântica is an especially vulnerable example of such a multifaceted problem. Indeed, the precarious situation in Bahia is due to centuries of dissonance between the requirements of the region's people and the needs of their environment.

Porder, VanWey, and the rest of the team know that neither the environment nor society can be rebuilt without establishing a sustainable sense of balance between the two. Combining social and ecological data with valuable insight from residents of the Sul da Bahia, the researchers hope to guide the Mata Atlântica into a new era of mutualism. If successful, their project will set the stage for the unprecedented restoration of a tropical biome, transforming it into a global model of ecological diversity and social prosperity. ■

The team also includes Jorge Chiapetti, Professor at Universidade Estadual de Santa Cruz (UESC).

INTRODUCING: DAWN KING

Newly named lecturer Dawn King has a passion for urban agriculture, not least of all because the way people produce food is rapidly changing. "A couple of years ago the world became more urban than rural for the first time in history," she says. "There isn't access to growing your own food where the populations reside, and that can be problematic."

King explains that urban agriculture can provide certain benefits, such as diversifying a region's food supply and protecting against big-farm problems such as livestock disease outbreaks. More distributed food growing could also make the country more resilient to climate change, which has the potential to shift where crops can thrive.

But King also teaches her students not to romanticize urban farming, as some people do. The argument that locally grown food produces less carbon emissions than the global food supply chain is often untrue, she says. And without huge economies of scale, small local growers of almost any commodity must charge higher prices than big food companies.

King is currently working on a book about how local food policies affect economic development and climate change resiliency. "One thing that's really powerful about state and local politics, which oftentimes people feel isn't quite as sexy as the federal level of politics, is that individuals can make a huge impact," she says. "You can do this on your own."

That's an idea King imparts to students. She came to IBES, she explains, to teach with a strong component of community engagement. "It's so amazing to work with student in engaged scholarship," she says. "It's just silly to teach this type of material without getting the students' hands dirty, literally and figuratively."

Adapted from content developed by David Orenstein

research spotlight

Graduate student **STEPHANIE SPERA** takes the birds-eye view on environmental change—literally. With help from the Environment And Remote TecHnologies (EARTH) Lab, an in-house facility that offers a wide range of high-powered tools for geospatial analysis, Spera spends her time turning complicated satellite data into discernible predictions about land cover change in the Cerrado, a large region of tropical savanna in south-central Brazil. Her research focuses mainly on how the enhanced vegetation index (EVI), or greenness, changes over time.

"If you have a year's worth of greenness data, you can sort of see how that changes and tell land covers apart," she explains. "If it's green the entire year, it's probably rainforest. If it 'greens-up' when it starts to rain and then 'greens-down' when it gets dry again, it could be pasture or savanna. If you see nothing or very low EVI, and then spikes in EVI, it's probably some crop that has been planted… If you see green and then all of a sudden [the EVI] drops, that patch of land has been deforested."

EARTH Lab's extensive bank of resources allows Spera to extract information about other attributes of the Cerrado as well, such as topography, slope, soil, and evapotranspiration, or the process by which plants release back into the atmosphere.

"I look at tons and tons of spatial data, and try to put it together and make a story over time—usually the past decade," she says. "The broader impact is to see how we are affecting the landscape and how the landscape is in turn affecting the climate, and then how people are responding to climate."

Spera would be interested to see how her conclusions about deforestation and evapotranspiration fit into different models of climate change, but she says she will leave that work to other scientists. For her part, she enjoys piecing together the world from above.

OPTIMIZING HEALTH: INSTITUTE TARGETS WELL-BEING AMIDST POLLUTION

It's a sunny day in Beijing. Pedestrians bustle about on the crowded avenues, inhaling the sweet perfume of a passer-by, the pungent aroma of fried delicacies… and a hefty serving of toxic particulates that linger in the city's thick air.

A "clear" day in Beijing. No fog, no clouds—just severe air pollution. *Photo: Gregory Wellenius*

These particles, microscopic collections of metals, organic matter, and other substances, find their way to the lungs, where they slip into the bloodstream, disturb delicate hormonal feedback mechanisms, or trigger a powerful inflammatory response, ultimately increasing residents' risk of cardiovascular events such as heart attack and stroke.

Gregory Wellenius, IBES Fellow and Associate Professor of Epidemiology and Public Health, knows that these kinds of health risks do not arise from air particulates alone. Although environmental health scientists tend to study atmospheric variables such as particulate matter, ozone, and ambient temperature in isolation, Wellenius explains that, in reality, they all interact—and often in ways that are complex and poorly understood.

Ozone, for instance, is protective when stored high in the stratosphere, but its high reactivity makes it profoundly hazardous here on the ground. In densely populated areas, pollutants such as vehicle exhaust and industrial emissions combine with heat and light to create molecules of ozone. The hotter and sunnier the weather, the more of these compounds that are produced, and the greater the risk for poor air quality. Climate change will likely amplify these effects, leading to adverse health outcomes that disproportionately affect the most vulnerable demographics: the elderly, and those who already suffer from heart or lung conditions.

"We know that there are going to be more hot days, and that those hot days are going to be hotter and more humid," says Wellenius. "So what is the likely health impact of that in people?"

Kate Weinberger, a postdoctoral associate who began her term with the Institute in September, hopes to answer this question. Weinberger will work with Wellenius, IBES climate modelers, and neighboring state health authorities to forecast likely heat and health effects in New England through the end of the century. She will draw on temperature records, hospital data, and future climate models to build up a robust picture of the ways that climate change may impact human health.

Weinberger's interdisciplinary project fits squarely within the Institute's human health and well-being research theme, which holds at its core the intimate, bi-directional relationships that exist between groups of people and their landscapes. Institute researchers like Wellenius and Weinberger cross disciplinary boundaries to study how various environmental stressors impact human health, how people adapt or fail to adapt to these stressors, and what kinds of social and cultural changes come about as a result. Above all, the Institute seeks to support and empower at-risk populations in the face of these challenges, fostering the health and well-being of both people and their environment.

Collaborations among IBES fellows frequently touch upon each of these goals. For instance, in many low- and middle-income countries, families burn coal, wood, or crop residue to cook their food and heat their homes, a practice that is necessary for survival but also extremely harmful to residents' health. Although four million people across the globe engage in this practice, relatively few studies have been done to tease out its precise effects on the body. Wellenius and other researchers at the Institute plan to explore the practice of unvented biomass burning and its health effects in more detail, focusing mainly on the highly vulnerable populations among which it is most prevalent.

Reflecting on the teamwork that went into conceptualizing this and other projects, Wellenius recalls, "It was just really exciting to have such a multidisciplinary, diverse team working together to a common goal. That was really what struck me that IBES is supposed to be about. That was sort of the embodiment," he continues. "We were across different themes and across different disciplines and brought very different expertise to the table, and we were all working really well together."

Wellenius believes that part of the magic of the Institute lies in the fact that it is housed at a relatively small university. "Larger institutions don't have the same need to collaborate across disciplinary lines the way we do," he explains. "We have top-notch people in each of the disciplines within IBES. By working together, we can really create new ideas and new advances in science that are not going to happen by people working within their own disciplines, how they traditionally do."

Wellenius believes that the Institute's collaborative strengths could also inform a more interdisciplinary educational experience for students. Already, several Institute undergraduates have benefitted from formal partnerships with faculty in the School of Public Health; moving forward, this relationship could easily extend in the opposite direction. "There are some existing ties between education in environmental sciences on campus and public health down the hill," he says. "There are lots of concrete examples that I can think of right off the bat of classes that we should cross-list and pre-approve for people to take as part of their concentrations."

After all, says Wellenius, "there's no question that Brown's undergrad students are just some of the best in the country… They come with such enthusiasm and fresh ideas that I think we can really learn a lot from them."

Brown University is already renowned for its brilliant students, accomplished postdocs, and expert faculty; in Wellenius' view, the main advantage of the Institute is its ability to get these parties talking. "I think that's where IBES can play a key role, by facilitating these connections," he explains. "The people already exist; now it's about facilitating the interplay among the great resources we already have." ■

faculty spotlight

Issues of environmental contamination are complex. There is often a striking disconnect between those who live in and around contaminated zones, those who know that such an arrangement poses a problem, and those who are ultimately responsible for directing clean-up efforts. For the last decade, the Brown Superfund Research Program (SRP) has been working to bridge these divides.

The Brown SRP fosters partnerships between representatives from academic, government, and community spheres in order to more effectively address environmental health and remediation concerns in Rhode Island. The program is comprised of four research projects and six "cores," or teams, that tackle different aspects of these contamination issues.

SCOTT FRICKEL, IBES Fellow and Associate Professor of Sociology, was recently appointed as leader to the program's Community Engagement Core, an arm of the SRP that works on multiple levels to engage involved parties in environmental health and justice issues. As Core Leader, he will oversee the team's outreach, education, and communication efforts at Brown, in the community, and with a variety of environmentally-focused state and federal agencies. Frickel says the team's work will include conducting neighborhood surveys, designing community-based research projects,

concentrating efforts to increase funding and resources for at-risk communities, and much more.

Frickel, an environmental sociologist, is also committed to exploring the sociology of science and technology, an endeavor that lends itself well to analysis of research projects such as the Brown SRP. "I am very interested in studying the program itself, as a knowledge system," he says. "In a way, I'm interested in studying my colleagues… to watch what they're doing and who they're talking to and how they're developing research questions, and how that information, the knowledge that they've produced is or isn't making its way into communities, into policy domains, into the private sector."

Frickel's colleagues include two other IBES Fellows: Biomedical project leader Agnes Kane and Engineering project leader Robert Hurt. The SRP has just been funded for another five year term, during which time researchers will attempt to tackle issues of regulatory uncertainty.

"Human agricultural and industrial activities have adverse impacts on rural and urban environments, both locally and globally. Interdisciplinary teams including social scientists, biologists, epidemiologists, and engineers are investigating the impacts of natural and anthropogenic environmental stressors on human health and well-being and developing novel strategies for remediation and prevention of future environmental contaminants."

Agnes Kane,
Research Theme Leader,
Human Health and
Well-Being

Earth, Itself 2015: THINKING THE EARTH

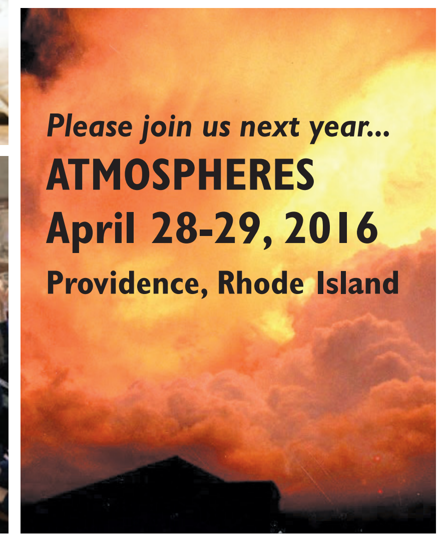
1. Conference convenor Lenore Manderson, Visiting Distinguished Professor in IBES and Visiting Professor of Anthropology at Brown

2. Dance program convenor Shura Baryshnikov engages in contact improvisation with fellow performers. Photo: Nikki Carrara

3. Keynote speaker Dan Nepstad argues that environmentalists and polluting industries must work together to secure a more sustainable future.

4. Keynote speaker Kekuhi Keali'Ikanaka'Oleohaililani introduces guests to *Kinolau*, a Hawai'ian linguistic scheme that emphasizes the oneness between the spoken word and natural processes.

5. Keali'Ikanaka'Oleohaililani leads conference guests in the creation of an original, venue-inspired hula.



VOSSES AIM TO 'ALIGN SCHOLARSHIP WITH THE NEEDS OF SOCIETY'

An astute businessman and his artistic wife may not seem like the prototypical supporters of environmental research and education, but Peter and Pamela Voss are a very socially-minded team. As magnanimous as they are successful, the Vosses have been among the greatest sponsors of Brown's dedication to this area of scholarship for years.

"Simplistically, we care about the planet," explains Peter, a '68 Brown alumnus. For both Peter and Pamela, maintaining an adequate water supply, generating and retaining sustainable forms of energy, and determining the trajectory of Earth's changing climate represent some of our society's most pressing concerns. "It's about quality of life for the people that are here today and tomorrow… We need to have some responsibility about how we use our resources," he says.

In addition to their broad support of faculty projects at the Institute, the Vosses also sponsor fellowships for distinguished postdoctoral associates and undergraduate researchers. Voss Postdoctoral Fellows hone their professional skills and help to diversify the Institute's breadth of expertise, while undergraduate Voss Environmental Fellows tackle investigative projects alongside accomplished mentors of their choosing. Both awards are designed to provide exceptional young scholars with the opportunity to conduct innovative research, the impact of which is magnified as they move through Brown and into the world beyond.

Despite the couple's overarching emphasis on sponsorship of research, Peter makes his appreciation of the classical education model very clear.

"I like the education side; I'm committed to Brown's undergraduate program," he maintains. "But somehow, you just think if you have the ability to increase the research orientation, maybe there are some solutions in there."

Besides, he says, "The [Environmental] Fellows enhance their education. So it is research, but it also is education of the undergraduate."

Peter reflects fondly on his own experience as a Brown student. "I think it helped mature me - helped me think, articulate, write, study various subjects," he muses, easily recalling a number of his favorite professors by name. "I found them very engaging. You could talk to them, engage in discussion and gain insight on the course or papers," he explains.

As the University closes the book on its 250th anniversary, the Vosses are enthusiastic about the way both teaching and research have evolved over the years. "I'm thrilled that we've formed the Institute, and I'm thrilled that Brown chose the environment as one of the key strategies going forward in our society," says Peter. "I think it's very important, and I think it touches on all aspects of science and also our future."

"It's an exciting time for Brown, an exciting time for this particular area of scholarship," he continues.

Asked what he hopes IBES will accomplish, Peter sets his sights high. "I hope we can help to educate and inspire some people to really make a difference in the environment and our society. We certainly have impressive faculty and students."

"It sounds very lofty and idealistic," he admits, "but I'm confident there's a great chance we can." ■

FEATURED FELLOWS: SUMMER 2015

ALEXANDRA SWANSON '16 worked with Stephen Porder, Associate Professor of Ecology and Evolutionary Biology, to investigate how different nutrient levels in Costa Rican forest canopies affect soil characteristics—and therefore, ecosystem biodiversity—on the ground. She gathered fallen leaves and other material from two sets of canopied environments (one nitrogen-rich, and one nitrogen-poor), and determined the amounts of organic material present in each. Swanson's work helped inform her group's understanding of how soil characteristics and other geochemical properties relate to biodiversity in canopied ecosystems.

PAUL WOJTAL '16 worked with Meredith Hastings, Associate Professor of Earth, Environmental and Planetary Sciences, to isolate and classify different isotopes of nitrogen that are found in reactive nitrogen species in the atmosphere. Wojtal used Hasting's method of isolation, a process that collects reactive nitrogen gases with 100% efficiency and allows more effective identification of different isotopes. His analysis of nitrogen isotopes found specifically in road-side gasses was meant to clarify the role of vehicle emissions in human-driven atmospheric change.

POSTDOCS

SARAH IVORY works "at the interface of the geosphere and biosphere," forecasting the ecological consequences of climate change by analyzing the evidence that past shifts have left behind. Her research has taken her from African mountain forests to the islands of Indonesia as a member of drilling expeditions seeking to extract ancient sediments from deep within the Earth. Such samples, or sediment cores, are chock full of fossilized pollen, from which Ivory can identify the vegetation that thrived in these regions hundreds of thousands—even a million—years ago. Based on her studies in Africa, Ivory has found that many alpine species' ability to tolerate climactic shifts has changed dramatically over time. Her work also suggests that many trees in this region are not as sensitive to temperature changes as had been previously thought.

ERIC ROY is a biogeochemist who is working to understand how both environmental and human factors influence the use of phosphate fertilizer in Mato Grosso, Brazil. Farms in this region produce 8% of the world's soybeans and rely heavily on finite, non-renewable phosphate rock for their fertilizer supply. Roy explains that, while the industrialized agriculture of Mato Grosso exemplifies a pathway for tropical regions to bolster their production of valuable food commodities, the sustainability of using phosphate fertilizers on nutrient-poor soils is not well understood. His research suggests that the soils of Mato Grosso will continue to require large amounts of fertilizer to remain productive for decades; in an effort to quantify regional needs, Roy has constructed so-called phosphorus budgets for individual farms, Brazilian states, and the nation as a whole.

ALEXANDRA SWANSON '16

PAUL WOJTAL '16

SARAH IVORY, PhD

ERIC ROY, PhD (back row, left)

HOW TO BUILD A RAINFOREST

IBES, Brown graduate students and RISD colleague unite science with art

A printmaker, a rainforest ecologist, and a biologist walk into an art studio. The three colleagues share a goal: to communicate the complexities of a tropical forest ecosystem in a way that is both visually striking and scientifically accurate.

Kate Aitchison, the partnership's artistic muscle, is a graduate student at the Rhode Island School of Design. Aitchinson has spent the last 8 summers working as a river guide and experiential educator focused on the Grand Canyon and the Colorado Plateau. "Those experiences have heavily informed my work as an artist," she says. "[They have] inspired me to create work that is connected to science and the environment as a way to connect viewers back to place and the importance of the natural world."

Last winter, reflecting on her interest in environmental stewardship, Aitchison reached out to a group of environmental scientists at Brown in search of collaborators for an independent student assignment. Brooke Osborne, a PhD student in Ecology & Evolutionary Biology (EEB) and graduate student at the Institute, gladly answered the call along with fellow EEB graduate student Robert Lamb, who helped to conceptualize the project.

Osborne, who studies nutrient cycling in the rainforests of Costa Rica's Osa Peninsula, has always been interested in creative methods of science communication. "Not only in terms of giving public talks or creating posters that are easily accessible," she explains, "but genuinely alternative ways to communicate science."

Osborne's research centers on tracing the path of key nutrients such as nitrogen and phosphorus from the ceiling of a tropical rainforest ecosystem to the trenches. This work requires her to alternate between examining remotely-sensed maps of nitrogen in canopy leaves and traveling to Costa Rica to measure the nutrient content of decomposing plant material that litters the forest floor. By quantifying the circulation of nutrients between these two regions, Osborne can better understand the way that such essential chemicals become incorporated into the biomass of other organisms.

Photos: Nick Missel

Aitchison's installation, a room-sized conceptual replica of a tropical forest ecosystem made entirely from her own printed paper, includes representations of both the canopy, a dense ceiling penetrated solely by feeble threads of light, and the damp, dark, verdant region below. Toward the bottom of the exhibit is a deep orange border, a stand-in for the rust-colored soil that separates the lush, visible part of the rainforest and its floor from the relatively nutrient-poor subterranean world. Peppered throughout this region are tiny red balls that represent root nodules, which house colonies of bacteria that excel at harvesting nitrogen from the air. Not all trees can accommodate this kind of mutualism, however, and so those that do have a distinct growth advantage. (They also make especially prized neighbors!)

Juxtaposed to all of this complexity, at the opposite end of the exhibit, stands an ersatz rainforest that is identical in every way except one: here, each element has been thoroughly bleached of all color, texture, and detail. The observer is urged to contemplate the stark divergence between the intricate world on his or her left with the barren wasteland of white on his or her right. Both Aitchison and Osborne hope that this dramatic contrast will convey the devastation that deforestation inflicts on the biosphere.

"It's been incredibly exciting and provocative to watch how Kate assimilates and transforms our empirical research into this vibrant, dynamic, and engrossing art form that communicates our ideas and scientific insight in a completely different medium," remarks Lamb.

Osborne adds that you don't have to be a scientist in order to understand the basic relationships that Aitchison's artwork attempts to illustrate. "You can tell from how dense and layered and colorful the exhibit is, whether you know about the science or not, that there are many complex mechanisms at work in intact tropical forests," she says.

"When you start to remove elements of that complexity, the dynamics of the system are altered," she explains, reflecting on the bleakness of the right half of the installation. "In the extreme case of deforestation, for example, an important change is that essential nutrients like nitrogen and phosphorus are no longer being assimilated and cycled by trees. They are being lost from the system."

"And certainly the major, most obvious difference is the loss of stored carbon that comes with the removal of forest biomass," Osborne emphasizes. "It's not insignificant at all, the amount of C that these rainforests store and keep out of the atmosphere."

Ultimately, Osborne and Aitchison hope to submit their project to universities or traveling art and science exhibits. "The goal is to reach a broader audience, and to reach them within a few minutes as they walk by and interact with Kate's installation," explains Osborne.

"I hope this project communicates a sense of how fragile and complex these ecosystems are, and what is lost when they are altered or destroyed," she concludes. "And I hope it also gives the viewers a sense of how inherently special and interesting they are as a place to go, or to have some vested interest in protecting or conserving."

"I hope viewers are inspired to reconnect with their own natural environments and think about the ways in which we use different environments for our own well being," adds Aitchinson. "I want to give people an entry point back into the environment in a way that's less abrasive and jarring than a lot of the news we receive today."

Osborne and Aitchinson are currently collaborating on a new project with Lamb and his adviser, Professor of Ecology & Evolutionary Biology Jon Witman. The team's forthcoming installation will center on oceans, drawing from Lamb's and Witman's work in the Galapagos. ■

AUTONOMOUS HELICOPTER EXAMINES TROPICAL FOREST ROLE IN GLOBAL CARBON CYCLE

Each year, fossil fuel combustion and other industrial processes release billions of tons of carbon into the Earth's atmosphere. About half of this carbon remains suspended there, while some is taken up by the oceans and temperate forests. But what happens to the rest?

The Brown Platform for Autonomous Remote Sensing. *Photo: Carlo Zgraggen*

Scientists believe that the "missing" carbon ends up being stored in tropical forests; however, the mechanism underlying this uptake remains unclear. Now, a new project spearheaded by IBES Fellow James Kellner aims to quantify the mechanisms of exchange of carbon between the atmosphere and the tropics by conducting remote sensing measurements in the Atlantic lowlands of Costa Rica. His tool of choice? A suite of sophisticated technology carried by a state-of-the-art unmanned helicopter.

THE MISSING SINK

Ecologists talk about carbon in terms of its different pools, or reservoirs, such as the oceans, forests, and atmosphere. Movement, or *flux*, between pools occurs due to biological processes, like photosynthesis and respiration, and geological processes, like rock weathering. When the flux of carbon into a pool—say, the atmosphere—is greater than the flux out, that pool is said to be a net *sink* for carbon; conversely, when the flux of carbon out of a pool is greater than the flux into it, that pool represents a net *source*.

Understanding these variables and the relationships among them is essential to tallying up the global carbon budget—especially since this budget currently contains a significant amount of uncertainty. "We can quantify the sizes of pools and fluxes. But when added up, the budget doesn't balance. There's some CO_2 emitted every year that does not remain in the atmosphere but is not directly accounted for by any known sink," explains Kellner.

Tropical forests may hold the key to understanding this so-called "missing sink" of carbon. Some researchers have suggested that, in the presence of a more carbon-rich atmosphere, photosynthesis enables tropical trees to grow faster. According to Kellner, however, there is no decisive evidence that this is the case.

"Some data show that aboveground carbon is accumulating, but we haven't ruled out a number of alternatives," he says. "In part, the problem is that the data that have been available are not directly related to what we want to understand."

Historically, scientists have measured carbon fluxes by making repeated measurements of tree diameter at a height of 1.3 m aboveground. As a tree grows over time, its diameter increases, and scientists have developed scaling equations that allow them to convert diameter into mass, in the same way that a person's height could be used to predict their weight.

But Kellner is skeptical of the assumptions underlying this method. "Not all growth shows up in tree diameters," he says, "and tree diameters can change for reasons unrelated to growth."

In his view, scientists have long needed a new way to measure the amount of carbon being taken up by tropical ecosystems. Enter the Brown Platform for Autonomous Remote Sensing (BPAR), an unmanned helicopter that brings together imaging spectroscopy, airborne LiDAR, and methods from computer vision to characterize the structure, composition and chemistry of natural landscapes in high spatial resolution.

Kellner is hopeful that BPAR's advanced instrumentation will capture the Costa Rican forest in a new way, enabling his team to gain insight into the physiological processes that drive carbon fluxes in the tropics.

A SPECTRAL SOLUTION

One way they hope to do this is by employing the drone's imaging spectrometer, an instrument that makes high-resolution measurements of the radiation reflected or emitted by substances in its field of view. These measurements reveal patterns that tell researchers something about the material that was analyzed. For instance, the reflectance spectrum of a green leaf will reveal a peak at wavelengths that correspond to green light as well as an abrupt increase in the near-infrared, a large bump that scientists call the *red edge*.

"If you see that, you're almost definitely looking at a green plant," explains Kellner.

"And there are more subtle features in the spectrum that tell us about the composition of the material in the sensor's field of view," he continues. "For example, whether the pixel contains soil, water or vegetation. Is it green vegetation, or dry? This kind of technology can also produce measurements of chemical properties in some cases."

Of course, spectroscopic measurements can do far more than simply identify leaves or woody biomass. Indeed, Kellner and the team believe that conducting imaging spectrometry of the tropical forest canopy will also help to quantify the carbon flux due to photosynthesis, the process by which plants take up CO_2 and employ it to make energy.

EXAMINING MOLECULAR MACHINERY

At the subatomic level, sunshine streaming through a forest canopy looks somewhat different from the diffuse, warm light we humans are familiar with. At such tiny scales, photons bombard chlorophyll molecules, occasionally colliding with enough strength to excite a bound electron to a higher energy state. This energized electron can be passed to other chlorophyll molecules in a photosynthetic process called *photochemical quenching*. Photochemical quenching is the ideal fate for an excited electron because it results in the production of molecules that plants use to remove CO_2 from the air—but it can only occur as long as the plant's machinery has available vacancies.

In the event that the plant's capacity for photosynthesis is saturated, it has two remaining options for ridding itself of an excited electron: emitting it as extraordinarily dim fluorescence, which can ultimately damage the plant's machinery, or releasing its excess energy as heat in a relatively harmless process called *non-photochemical quenching*. The trick, for scientists, is to differentiate the three mechanisms, a goal that is complicated by the fact that neither photochemical quenching nor non-photochemical quenching can be measured directly in ecosystems.

Natural color composite image of the rainforest canopy.

False color composite image of the rainforest canopy. Here, rosy-colored pixels correspond to material that has high reflectance in the (normally invisible) near-infrared part of the spectrum. Green-colored pixels reveal carotenoid-rich flowers that reflect relatively less near-infrared radiation.

But fluorescence, although extremely faint, is detectable. BPAR's high-resolution imaging spectrometer will enable Kellner's team to quantify this fluorescence by making repeated measurements of the rainforest canopy under a variety of different conditions.

Additionally, by measuring the net flux of carbon between the forest and atmosphere, the team should be able to build a model that will allow them to infer the total amount of photochemical quenching that is occurring in the forest. And once they know the contributions from two out of three photosynthetic mechanisms—in this case, fluorescence and photochemical quenching—they will be able to deduce that of the third, completing the triad.

In other words, BPAR's ability to detect fluorescence is like a key that will unlock the scientists' ability to paint a more complete picture of photosynthesis and, therefore, better identify the determinants of carbon fluxes in tropical forests.

Then, Kellner and his team will finally be able to take on a wider goal: critically evaluating the physiological underpinnings of carbon exchange between tropical forests and the atmosphere. Ultimately, Kellner hopes that the results of this evaluation will help determine whether or not tropical forests are likely to indeed be the "missing sink".

"If we can get to the point, as a discipline, where we can accurately infer carbon fluxes from fluorescence, then we will understand the uptake side of the equation," he says.

SOPHISTICATED AND PRACTICAL

Imaging spectroscopy is not BPAR's only specialty. The drone also carries high-resolution visual imaging equipment and a LiDAR sensor.

LiDAR, or Light Detection And Ranging, is a technology widely used in remote sensing that measures the amount of time it takes for pulses of light to bounce off a target and return to a sensor. After calibration for location and direction of fire, these data points can be transformed into an elevation map—in this case, of the rainforest canopy. Researchers can combine the results of spectroscopy and digital imaging with the elevation map created by LiDAR in order to create detailed false-color images of the forest from above.

"This allows us to 'see' in wavelengths that are otherwise invisible to the human eye, like near infrared." explains Kellner. "Then you can visualize how biological materials are structured spatially in 3D. It's powerful. Things become clear when you can see in that way."

BPAR's strength lies, in part, in its flexibility. "With pixels as small as 1 cm, it increases by one to two orders of magnitude the spatial resolution of measurements relative to other airborne imaging spectroscopy systems," he says. "And because the cost of operation is more manageable than a traditional remote sensing program, BPAR can be deployed repeatedly and frequently."

"The timing of data collection can be dictated by the scientific questions," he adds, "rather than the questions being dictated by the timing of data collection."

The Brown Platform for Autonomous Remote Sensing boasts cutting-edge instrumentation and the capacity for extraordinarily high spatial resolution, all at the hands of a brilliant team of researchers and technicians. But, Kellner emphasizes, its real value lies in the potential it offers to science.

"[BPAR] is not just a technical flourish," he says. "What it's really about is about generating the ability to collect the right kinds of measurements to answer the questions that are unresolved." ■

Kellner's research collaborators include IBES faculty fellows Jung-Eun Lee, Jack Mustard, and Stephen Porder; Brown faculty member Ralph Milliken; staff members Henry Johnson and Joe Kendrick; post-doctoral scholars Sandra Wiseman and Xi Yang; graduate students K.C. Cushman and Carlos Silva; and Brown undergraduate Lucas Toh. The project also includes David and Deborah Clark of the University of Missouri.

The project is funded by the National Science Foundation (GR526257).

"The Earth System is by nature dynamic, and past episodes of global climate change have much to tell us about the complex interactions between climate and biodiversity. The Natural Systems theme unites Brown research strengths in paleoclimate, ecology, and evolution to understand and improve the fate of all living organisms in the face of escalating human-driven global change."

Erika Edwards, Research Theme Leader, Natural Systems

INTRODUCING: LINT BARRAGE

Most environmental experts would argue that any discussion of economic strategy is incomplete without consideration of its environmental impact; less often publicized, however, is the effect that environmental legislation has on a country's economic productivity. But according to Lint Barrage, economist and newly-minted IBES Fellow, a thorough understanding of the economic ramifications of environmental policies (e.g., fossil fuel taxes) is vital to both the country's fiscal and ecological health.

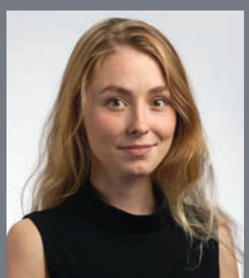
Barrage's research measures the feedback between financial systems and environmental processes such as climate change. For instance, she says, "the economy grows and burns more fossil fuels [and] that changes the climate, which, in turn, affects the economy through effects ranging from agricultural productivity changes to lower labor productivity in countries affected by higher malaria incidence." With a sound understanding of these feedback mechanisms, she explains, policies can ultimately be optimized for efficiency and productivity.

Formerly Assistant Professor of Economics at the University of Maryland, College Park, Barrage earned her Ph.D. in Economics with Distinction from Yale University in May 2013. Her interest in economics has environmental roots; as an undergraduate at the University of Chicago, she was fascinated by the role of economic rationale in the process of environmental policy-making.

Barrage is looking forward to advancing her work through collaboration with other disciplinary experts at IBES. "In order to study the channels through which the environment affects economic productivity, you have to understand the natural science and human health side of things," she says. "I really could not be more excited to be joining this community of scholars!"

student spotlight

Throughout her time at the Institute, **ALEXIS DURAND '16** has devoted her studies to the rights of at-risk populations. At the poster session preceding last spring's *Earth, Itself* event, she was awarded first prize among undergraduates for her work highlighting a populace whose vulnerability is often under-recognized: prison inmates.



"Prisons may be more vulnerable spatially, as they are often marginalized through the hazardous location and isolation of facilities," explains Durand. "They are also vulnerable socially, because they lack access to economic opportunities, care, and interpersonal relationships."

"Additionally, prisoners are not always able to make independent decisions to protect themselves during a disaster," she says.

This last point was exemplified during the January 2014 Elk River Chemical Spill, in which 7500 gallons of coal-washing chemicals were accidentally discharged into the heart of central West Virginia's water supply. Durand's research suggests that, despite a strict water ban, inmates at Charleston's South Central Regional Jail did not necessarily have widespread access to clean drinking water during this time.

Durand recounts: "After the spill, West Virginia Governor Earl Ray Tomblin reassured the state that, 'It's your decision. If you do not feel comfortable drinking or cooking with this water, then use bottled water.' However, Governor Tomblin failed to recognize that some residents are unable to make a choice to switch water sources."

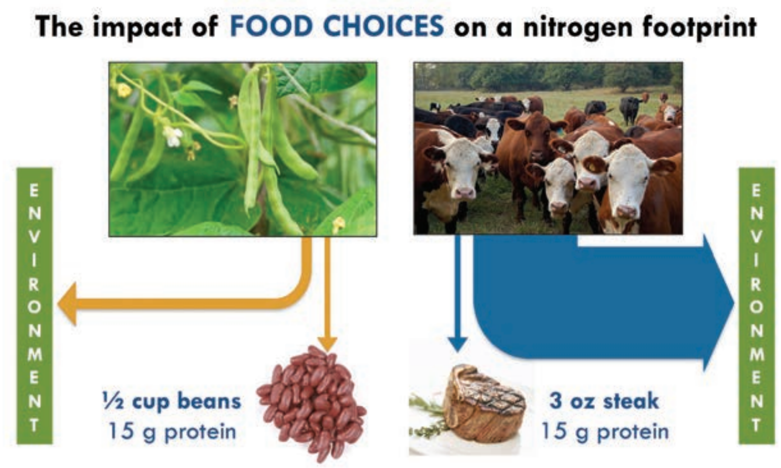
As industrial productivity and climate change continue to drive up the frequency of such disasters, many individuals living in the most at-risk communities both nationally and internationally will be in greater need of both advocacy and protection. Thanks to her engaged, interdisciplinary work, Durand is well positioned to fill these roles and to serve as a future spokesperson for the most marginalized among us.

After she graduates next spring, Durand hopes to work in international climate change policy as a policy advisor.

BROWN'S NITROGEN FOOTPRINT

UVA-led project comes to Providence

Carbon compounds are arguably the most infamous of all the greenhouse gases, but they are not the only chemical offenders deserving of concern. In fact, nitrogen is capable of causing severe damage to the environment as well. This simple element, harmless when safely bound in pairs in Earth's atmosphere, becomes extremely volatile when generated by human activities. Indeed, when combined with other elements such as hydrogen and oxygen, so-called reactive nitrogen compounds wreak havoc on the environment.



Far more nitrogen is released to the environment during meat production (blue arrow) than during production of legumes (yellow arrow), despite the fact that beans and beef contain the same amount of nitrogen as protein. This is because meat production - which requires raising animals as well as the crops they eat - has more pathways through which nitrogen can be lost to the environment. *Image: University of Virginia*

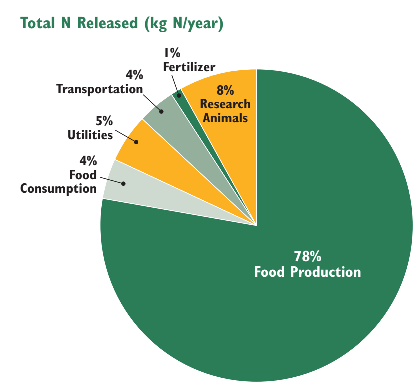
Although reactive nitrogen is also produced in nature, human methods of mass food production have outstripped even the most prolific nitrogen-producing ecosystems. Since the 1970s, we humans have driven greater numbers of our species up the food chain by consuming more animal protein and crops such as legumes than ever before, all the while releasing higher and higher levels of reactive nitrogen into the environment around us.

Nitrogen, in this sense, is both a boon and a curse.

Therefore, the question driving scientists is one of balance: How can we humans be responsible about our nitrogen emissions while simultaneously advancing the world's societies?

Enter the Nitrogen Footprint Project, a venture spearheaded by the University of Virginia and funded by the Environmental Protection Agency that aims to help others analyze and decrease their nitrogen emissions. Over the last year, Brown University and five other institutions have worked with a team of UVA scientists, including lead researcher James Galloway, project manager Elizabeth "Izzy" Castner (Brown '14), and the Footprint model's designer Alley Leach (now at UNH) to derive a clearer picture of their own institutional footprint.

The culmination of this first round of calculations occurred this past June, at a three-day conference hosted by the Institute. IBES Fellow Meredith Hastings and Postdoctoral Fellow Becca Ryals, who have been working on the project since its inception, presented Brown University's results:



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research spotlight

As an undergraduate in the United Kingdom, **CHELSEA PARKER** developed a deep appreciation for numerical models and their capacity to inform the study of vulnerable ecosystems. Here at the Institute, she has channeled that enthusiasm into her doctoral research: relating simulations of hurricanes on the northeastern coast of Australia to the development of algal blooms that threaten the fragile Great Barrier Reef.

"I've been building these numerical weather simulations to replicate hurricane events that have already happened in this region," she explains. "I use that tool to understand those systems… particularly their development, intensity, size, and how they track. With this understanding, I can then use remote sensing data to think about how the characteristics of the events translate to damage on the reef."

Reef organisms are threatened by a fairly straightforward chain of events: a hurricane moves into the region, triggering heavy rain and a powerful storm surge that floods the shoreline. Flood waters recede after the hurricane passes, dragging layers of pesticides, fertilizers, and sediment from coastal farmland back into the ocean. This influx of nutrients then drives an algal bloom that swiftly coats the surface of the water, absorbing most of the incoming light and leaving few nutrients for the bottom-dwelling organisms below.

Parker also runs simulations of these types of storms under altered climatic conditions, generating information that can be used to infer the threat posed by hurricanes in the face of a global changing climate.

"The simulations show that hurricanes appear in the future to be more intense," she says. "Wind speeds increase on average by about 15 percent, which would actually bump them up into a new intensity category on the hurricane scale. With the simulations, you can analyze how these hurricanes are responding to climate change and then relate that back to the index of damage over the reef [from past events] that I've created. Then you can see if future events would be associated with bigger algal blooms."

She is hopeful that the analysis she generates will ultimately prove useful to environmental protection agencies like the Great Barrier Reef Marine Park Authority in targeting their resources. "In the future, if you have a hurricane coming into a region, you will only need three things," she explains. "If you know the size, speed and intensity, you can predict what the algal bloom will be over the reef."

Nitrogen Footprint, continued

Their analysis was enlightening. Food production is far and away the largest contributor to Brown's nitrogen footprint, mostly due to the processing of and waste from animal protein sources.

So how can the University begin to reduce its nitrogen footprint? Local initiatives such as the Real Food Challenge and composting of food waste, together with an increase in the use of organic products and number of vegetarian offerings at campus dining facilities, may help to cut this largest source of reactive nitrogen emissions. Similarly, composting animal bedding after use and employing smaller laboratory creatures such as fish could help to reduce emissions from the research animal sector.

The nitrogen footprint calculation made a splash at Brown, proving itself to be a unique and innovative way of critically analyzing the University's environmental impact. Moving forward, Hastings and Ryals are optimistic that their continued efforts will support the adoption of further sustainability measures, paving the way for future cohorts of the Nitrogen Footprint Project to do the same. ■

"The greatest challenge of the 21st century is to achieve sustainable and equitable food production and water distribution systems. IBES researchers investigate the relationships between food, water, and people on five continents and across a hierarchy of timescales to understand the environmental and social factors that affect the development of different food production and water distribution systems, as well as the consequences of these systems on environment and society."

James Russell,
Research Theme Leader, Food and Water

THE ROAD TO PARIS

Fifth cohort of IBES undergraduates to attend UN Climate Summit

This fall, a dozen undergraduates from the Institute's Climate and Development Lab (CDL) will enroll in a course called *Engaged Climate Policy at the UN Climate Change Talks*. For one week in December, the climate negotiations and the Parisian streets will become the students' classroom, as they join 20,000 country delegates, civil society representatives, journalists, and thousands of citizens in their debate of one of the most important issues of our time. Timmons Roberts, Institute Fellow and Ittleson Professor of Environmental Studies and Sociology, founded the CDL in 2010. Roberts has been attending the climate negotiations since 2003 and has since built up an impressive list of professional contacts: a veritable Who's Who in climate change leadership. These contacts, along with Roberts' expertise and a chance to attend the UN climate talks, make competition for entry into the lab and course understandably steep.

But for a lucky few, their successful admission represents the opportunity of a lifetime. Since the introduction of the *Engaged Climate Policy* course, over 40 students from ten concentrations have attended the UN climate talks, traveling to such far-flung locations as Cancun, Durban, Bonn, Warsaw and Lima. Some return to the talks the following year as CDL alumni; others network their way into "embedded" roles within country delegations and NGOs.

From left to right: Jeffrey Baum '15, Professor J. Timmons Roberts, Alison Kirsch '15, Victoria Hoffmeister '17, and Cassidy Bennett '15.

"Olivia Santiago ['16], who took the class in Fall 2014, is now with the Seychelles delegation," offers Guy Edwards, IBES Research Fellow and co-director of the CDL along with Roberts and recent PhD recipient David Ciplet. "She has a country delegate badge, which means she can access any part of the negotiations normally closed off to journalists and NGOs."

Other students have made impressive professional contacts as well. For instance, Saleemul Huq, Senior Fellow at the International Institute for Environment and Development (IIED), has been working with Alexis Durand '16 and Victoria Hoffmeister '17 since 2014 and, at last year's talks in Lima, immediately put them to work investigating the Loss and Damage Mechanism for the Least Developed Countries Group (LDC). Maria Camila Bustos '16 and Ximena Carranza Risco '17 made a similar connection with Monica Araya, Founder and Executive Director of the think tank Nivela; the two now hold research positions with the organization.

"We're very small, the lab group, so we've made the most of these contacts we have at much bigger or influential organizations. We have the student resources, so on a number of occasions these organizations have just called us and said, 'Do you have someone that could help with this?' or, 'Can you suggest someone who might be interested in that?'," explains Edwards.

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Road to Paris, continued

"The students have a solid base in UN climate policy, so if they are interested in the work on offer they can really hit the ground running."

Roberts and Edwards recount the story of Brianna Craft, M.A. '13, who volunteered to fill one of these requests—a call for support from Pa Ousman, The Gambia's Minister of Environment, Climate Change, Water Resources, and Parks and Wildlife and former chair of the Least Developed Countries group. "She was essentially his personal assistant at the UN talks in Doha in 2012," recalled Edwards. "At the final meetings of the negotiations, when just certain people were in the room to draft an agreement, she was sat just behind Ousman, taking notes, with other ministers and top negotiators from the U.S. and other countries." Craft is now based in London at the IIED and continues to work closely with Ousman and the LDCs.

Roberts believes that such access to key players in the climate change debate offers members of the CDL a more nuanced perspective than they would get otherwise. "One of the students said last year, 'I was surprised at how human the process is,'" he remembers. "You can read about climate change politics in the books all you want, but when you actually know the personalities of the people and you see them again and again in different negotiations or out in the hallways… There's just nothing like being there."

During their week-long stay in Paris, this year's cohort will observe as many of the open-door negotiations as they are able; however, they will also spend time setting up meetings with target contacts, conducting interviews, attending side events, visiting with activist groups, blogging, and posting to social media. Roberts, Edwards, and Ciplet believe that the students' activities at the negotiations, as well as the research, writing, and policy-making skills they develop as members of the CDL, are a valuable complement to their more traditional academic studies.

This year's summit in Paris is charged with finalizing a new global climate deal to come into force by 2020. As thousands of negotiators, analysts, and campaigners prepare for this crucial meeting, twelve fresh faces here at IBES are gathering their own scholarly materials, professional contacts, and confidence, and bracing themselves for participation in an event with the loftiest of goals: building a low carbon and more resilient future for us all. ■

For ongoing updates, visit the CDL website at www.climatedevlab.org/ and follow @ClimateDevLab on Twitter.

"Better understanding and management of environmental conditions requires a deep understanding of how social, political, cultural and economic institutions do and should interact with the environment. Members of the Equity and Governance theme explore this issue at multiple levels: from evaluating the barriers to an equitable global distribution of the costs of climate-change mitigation and adaptation, to considering how poorly resource government institutions in low-income countries can best assure compliance with regulatory standards, to examining how subsistence farmers learn and adapt to the changing availability and quality of water."

Andrew Foster,
Research Theme Leader, Equity and Governance

BRING A COOL GLOBE TO LIFE

Undergraduates' hot idea spotlights worldwide deforestation

In 2007, colorful fiberglass orbs began appearing in cities all over the world. The sculptures, an assemblage of human-sized Earths that depict various artists' solutions to climate change, belong to an exhibition entitled *Cool Globes: Hot Ideas for a Cooler Planet.* The brainchild of environmentalist Wendy Abrams '87, the globes are meant to spark public engagement surrounding looming environmental threats.

The exhibition debuted in Chicago and later traveled to such disparate locations as Washington, D.C., Houston, Copenhagen, and Jerusalem. At the conclusion of the Boston showing in 2013, Brown University received a special gift: an Earth of its very own.

Brown's globe is now at the mercy of two undergraduates with a winning idea: blanket the sculpture in a thick coat of ivy that will wilt or thrive in accordance with regional deforestation patterns.

"We wanted a 'live globe,'" emphasizes Macklin Fluehr '17.

Fluehr and his partner in the project, Kenta Kondo '17, are both engineering concentrators with a passion for sustainability. "The main prompt of the design was to create something that addressed an environmental problem around the world," says Fluehr. "So we looked at a bunch of different issues, and did a lot of preliminary research… and we thought deforestation would be a good topic, because it covers such a broad area of the globe."

Kenta Kondo '17 (left) and Macklin Fluehr '17 (right) plan to illustrate global deforestation with deciduous and evergreen species of ivy.

Deforestation is not only widespread; it is also an enormous environmental problem. "The size of Panama is lost each year," says Kondo, quoting the United Nations' Food and Agriculture Organization's estimate of the extent of global deforestation. "We thought that was pretty bad."

Fluehr and Kondo worked with Kurt Teichert, Senior Lecturer of Environmental Studies, and David Tobe '17, Urban Environmental Lab garden coordinator, to devise a plan. Then, in early August, the two students planted two different kinds of ivy in the ground beneath the sculpture: evergreen English ivy and deciduous Boston ivy. Once the vines mature, the two will guide each type of ivy to a particular region of the globe —English ivy to areas where forests are mainly intact and Boston ivy to those areas that are threatened by high rates of deforestation, such as parts of the Amazon, Congo, Indonesia, Thailand, and eastern Australia.

"The English ivy stays green throughout the year, but the Boston ivy will change color," Fluehr explains. "In the Fall, it's going to turn red and yellow and orange. In the Winter, it will lose all its leaves. And in the Spring, it will come back as green, along with the English ivy."

Fluehr and Kondo are hopeful that both visitors and the wider Brown community will be inspired by this transformation.

"In the fall, the Boston ivy shows where we're headed if we don't do anything. And then in the Winter, forests are gone. But in the Spring, it shows—well, maybe there is an alternative," says Fluehr. "Maybe there's a chance we can get the forests back if we get things moving." ■

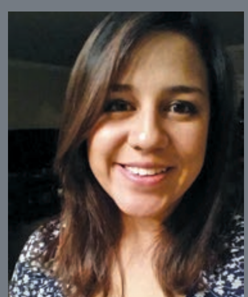
UNDERGRADUATES

We have launched a new curriculum that focuses on developing young scholars who have disciplinary strength together with multidisciplinary exposure. Transferable skills are built in our core classes, while deep dives into one of four tracks encourage grounded expertise. The students come together in their senior year to engage in capstones that encourage integrative scholarship and problem solving. This approach is a reflection of the faculty of of the Institute: a community of productive researchers, active in our respective disciplines. In this context, our students are immersed in solving sustainability challenges in ways that entrain the state of the art in natural and social sciences.

When Environmental Studies and Environmental Science concentrators leave Brown, they are prepared to become leaders shaping a sustainable future. ■

student spotlight

MARIA CAMILA BUSTOS '16 gives new meaning to the phrase *engaged scholarship.* Bustos, a member of the University's Climate and Development Lab, has been involved in climate activism, divestment efforts, and multiple environmental campaigns throughout her time at Brown. She is also resolutely committed to dissecting and communicating the climate policies of her native Colombia. "Climate change, to me, is the most important issue in my life," she says. "I think it will define, and is defining, my generation."



In Bustos' view, global climate change is not just an environmental issue; rather, its entrenchment in countless other areas of our lives and economies make it a social, political, and fiscal one as well. "It's also an equity issue," she adds, "because Colombia, which has contributed… less than 1% of total [greenhouse gas] emissions remains highly vulnerable."

Indeed, despite their home nation's extremely progressive climate policies, the people of Colombia continue to bear the brunt of global emissions. "My country is already suffering from impacts—changing rainfall patterns, droughts, El Niño; the glaciers in the Andes are melting, and that's threatening water supplies," Bustos explains. "There's this whole series of effects. And that's affecting who? The poorest and the most marginalized communities."

Last summer, Bustos completed an internship in Colombia that allowed her to examine coal extraction through a human rights lens. "It's very interesting because we have a very progressive position [at the United Nations climate negotiations], and then internally our main two exports are still oil and coal. Obviously with those exports, there are a lot of human rights violations," she says. "And I'm interested in that side as well."

Bustos is quick to credit her education and professors as the driving forces behind her extensive involvement with climate politics. "I'm really grateful for all the things I've learned at Brown," she says. "What I have learned inside and outside of class has been so helpful in shaping the things I'm doing now." She adds, "Obviously this is nothing that I've accomplished by myself."

Make a Gift

Gifts to IBES are used to provide 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.

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