

# CANOPY

FALL 2018

**(THE VIEW INSIDE A LEAF)** Page 18



### Say Cheese!

Yale-Myers Forest, in northeastern Connecticut, is home to a wide variety of species, including the eastern coyote. This specimen was snapped this summer by a camera trap set up by Kimi Zamuda, a conservation biologist conducting research on the distribution of meso-predators in New England. Zamuda hopes to use the camera traps to gather data to explain changes in predator species throughout different altered habitat types and inform conservation decisions.





# Looking Forward

With this Fall 2018 issue, *Canopy* magazine is now five years old and we celebrate that milestone with a change in direction, a refreshed design, and a new editorial team.

From the beginning, *Canopy* has been a showcase for the ways that the Yale School of Forestry & Environmental Studies (F&ES) — including our vast alumni network — provides innovative leadership in addressing the environmental challenges of our time. It will continue to be that. And, we hope, something more.

Our alumni will continue to be the lifeblood of this magazine, with articles and interviews about their work in every issue. We will still share highlights from our annual reunion each fall.\* And each spring we will publish Class Notes and the In Memoriam section.

However, we believe *Canopy* can be more than just an alumni magazine. The impacts of the entire F&ES community cut across all scales, sectors and geographies, connecting to other unfolding efforts. Our editorial vision will reflect that, through an increased emphasis on storytelling that places School's contributions in a broader context.

We hope you like what you see and read in these pages, and that you are inspired to suggest stories about F&ES people and programs that are making this planet a more sustainable place.

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\*Our Honor Roll of giving is now published in a separate Annual Report each fall, which is available online ([environment.yale.edu/annual-report](http://environment.yale.edu/annual-report)).

# CANOPY

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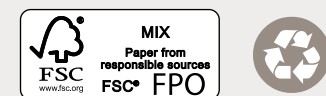
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**ON THE COVER**  
Detail from a micro-CT 3D scan of the inside of a spinach leaf. Explore the 3D model at this URL [yalef.es/spinach](http://yalef.es/spinach) and see page 18 for the full article.

COVER IMAGE COURTESY OF CRAIG BRODERSEN

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SAM MARDELL

Kimi Zamuda '19 M.E.Sc. set up camera traps in Yale-Myers Forest this summer as part of her research project on the distribution of meso-predators in New England. The cameras have captured deer, foxes, coyotes, and even black bears.



## Editing Nature: A Call for Careful Governance of Environmental Gene Editing

In Burkina Faso, the government is considering the use of genetically modified mosquitoes in hopes of eradicating malaria. In Nantucket, Mass., officials are looking at gene editing as a tool in the fight against Lyme disease. And scientists are using gene technology to make coral more adaptive to changing ocean conditions from the Caribbean to the Great Barrier Reef.

Yet for all the promise of these technologies, there remain profound concerns about the potential unintended consequences of releasing gene-edited organisms into the environment — and a lack of governance oversight.

In a new paper published in *Science*, an interdisciplinary group led by Yale researchers argues for new global governance to assure a neutral and informed evaluation of the potential benefits and risks of gene editing. They say

that the complex nature of these technologies requires, on a case-by-case basis, careful and judicious review — a decision-making process that must include the local communities that would feel the biggest and most immediate effects.

“The biggest risk right now with this technology is the uncertainty associated with it,” said Natalie Kofler, an associate research scientist at F&ES and lead author of the paper. “In some African nations, for instance, it is being touted as a silver bullet to get rid of malaria. But these technologies also have the potential to forever change the genetic makeup of species, or even drive certain species to extinction. Lack of global governance puts our planet at risk.”

The group proposes formation of a new coordinating global body with the power to convene communities, developers, governmental organizations, and NGOs to assure careful and

inclusive deliberation over all proposals.

“There are many proposals to release gene edited organisms into the wild and even actively drive them into the genomes of native wild populations to address a wide range of environmental issues,” said Oswald Schmitz, the Oastler Professor of Population and Community Ecology at F&ES and director of the Yale Institute for Biospheric Studies. “But this is all proceeding at a heady pace with very little discussion with potentially affected communities. Formal safeguards are needed to ensure that these well-intentioned technologies don’t unintentionally spread globally to destroy ecosystems and human welfare and cultures that rely on them.”

The paper was inspired by the Editing Nature Summit, hosted at Yale in 2017.

## F&ES at Global Climate Summit

In September, members of the F&ES community participated in the Global Climate Action Summit in San Francisco, including Dean Indy Burke, a group of students and several alumni. Casey Pickett ’11 M.E.M./M.B.A., director of the Yale Carbon Charge project (see page 25), presented on the innovative program during the gathering. Pictured (from left) are Matthew Moroney ’18 M.E.M., Franz Hochstrasser ’18 M.E.M., Courtney Durham ’19 M.E.M., Paul Rink ’19 M.E.M., and Anna Carcamo ’19 M.E.M.



## Diversity and Inclusion Initiatives Begin to Take Shape

In 2017 F&ES unveiled an ambitious strategic plan which prioritized, among other initiatives, diversification of the School’s student body, faculty, and staff in an effort to better address the complex environmental issues of the 21st century.

Beginning with the hiring of Thomas Easley as assistant dean of community and inclusion last year, significant strides have already been made within the F&ES community — and will continue to be a priority.

*“We must take the opportunity to engage all members of our community as we evaluate the myriad dimensions of our legacy as a school, articulate what we want to be, and engage in environmental scholarship that embraces social justice in the most inclusive way possible.”*

- DEAN INDY BURKE

Here is some of the progress, so far:

- Narasimha Rao was named assistant professor of energy systems analysis (see story below). Much of Rao’s work focuses on the link between energy and poverty, as well as the relationship between energy policy and income inequality.
- MODs, the School’s summer orientation sessions for incoming students, were revitalized to include two days of training dedicated entirely to diversity and inclusion.
- The Office of Community and Inclusion added staff through the hiring of Yolanda Quiñones as assistant director.
- Several new courses were created with a focus on environmental justice, including two capstone courses taught by Marianne Engelman-Lado, a former attorney at Earthjustice and the NAACP Legal Defense Fund, and a course taught by professors Michelle Bell and Amity Doolittle.
- Programming and events to promote an inclusive culture are ongoing, including presentations and workshops featuring renowned scholars, advisors and consultants.
- The School introduced a website to track its continued conversations on diversity and inclusion, and to invite feedback: [environment.yale.edu/community](http://environment.yale.edu/community)

## F&ES Welcomes New Professor of Energy Systems

Narasimha Rao was a young visiting faculty member in Bangalore, India when he came to truly understand the profound ways that energy policy decisions impact ordinary people.

In the years since, he has devoted his career to studying income inequality, infrastructure, and climate policy.



In January 2019, he will join the F&ES faculty as assistant professor of energy systems analysis.

“I started my career on the technical side, as an engineer,” he said. “But as I began to understand development issues and strategies more and more, I started to realize that many of the challenges are political, institutional, and social. So I gradually moved away from the technical side and tried to better understand the context of energy and society.”

Rao comes to Yale from the International Institute for Applied Systems Analysis (IIASA), which conducts research into global, environmental, economic, technological and social change. At IIASA, he has led the institute’s innovative Decent Living Energy project, which has helped quantify — and map — the energy needs and climate change impacts of eradicating poverty and providing “decent” living standards for all humans.



### Stylish Sustainability

Students Greg Chung '19 M.B.A., left, Jessica Harpole '20 M.E.M., Perry Leung '19 M.E.Sc., Emily Auerbach '20 M.E.M., Stephanie Hsiung '19 M.E.M., and James Souder '18 M.E.M. competed in a case competition for the outdoor clothing brand Patagonia, placing third. Teams were asked to present plans on how Patagonia can lower carbon emission effects of production, consumption, and disposal.



### Shifting the Mindset of Corporate America

Abigail Barnes '16 M.E.M. started exploring models for corporate social responsibility while launching her own company, Allergy Amulet.

As she saw it, an emerging group of tools — including “benefit corporations” and Certified B Corporation certification (“B Corps”) — was seizing on a shifting mindset in corporate America towards a more ethical and socially responsible way of doing business.

Barnes, who is also an attorney, wanted to build a business consistent with her values. She also believed these models offered a better — and smarter — way of doing business. “It has become increasingly clear that the corporate emphasis on short-term profits has come at the expense of worker well-being, communities, and the environment,” she says. “The rising number of benefit corporations and B Corps is largely a response to that realization.”

But she also found it was difficult to get clear answers to many basic questions about how they work. To quell this confusion, she has spent several years advocating for them. She published guidebooks for the business, legal, and legislative communities — including “An Entrepreneur’s Guide to Certified B Corporations and Benefit Corporations,” published by the Yale Center for Business and the Environment and Patagonia.

She recently organized a fundraiser to promote awareness in Wisconsin. And last year, she helped convince Wisconsin lawmakers, including conservative Gov. Scott Walker, to pass legislation that enables businesses to incorporate as benefit corporations.

“Pushing this initiative forward on different fronts — the policy side, the legal side, the corporate side — has proven critical to moving the needle forward.

### Terry Baker Named CEO of Society of American Foresters

This fall, Terry Baker '07 M.F. was named new chief executive officer of the Society of American Foresters (SAF), a scientific and educational organization that represents the forestry profession in the United States.

Baker had previously spent his entire professional career with the U.S. Forest Service, reaching the level of district ranger by the time he was 30. He most recently served as deputy forest supervisor on the Arapaho and Roosevelt National Forests and Pawnee National Grassland in Fort Collins, Colo.

He has been praised for a leadership style built on relationships and establishing trust and openness within the organization, as well as with the community and external partners.

“I view this as a great opportunity,” Baker said. “I value this profession and want to help it as it evolves and moves into its next chapter.”

### Sustainability and Smartphones: Brand Matters More than Hardware

Many critics have denounced smartphone manufacturers for making devices that quickly become outdated, creating a “planned obsolescence” that is costly for consumers and the planet.

But while many clamor for increased “repairability” for these devices, a recent Yale-led study found there’s a more important factor in determining how long smartphones remain in use: brand cachet. After analyzing roughly 500,000 eBay listings for secondhand Apple and Samsung phones, researchers found that the intangible property of “brand” is more important than repairability or memory size in extending product life.

How important? They estimate that iPhones, on average, last more than a year longer than Samsung phones even though the two brands are comparable in quality and technical innovation.

“Perhaps we should be focused on what really makes us replace phones so quickly,” said Tamar Makov, a doctoral student at F&ES and lead author of the paper, published in the *Journal of Industrial Ecology*. “Or we should be angry at manufacturers for making really good commercials.”

### Chen to Head Surdna Foundation

Don Chen '89 B.A., '92 M.E.S., was recently named president of the Surdna Foundation, a New York-based charitable institution that fosters sustainable communities through the support of social justice reform, healthy environments, and inclusive economies.

Chen previously served as director of the Ford Foundation’s “Just Cities & Regions” program. In that role he helped transform the foundation’s approach to urban development strategies, which targeted poverty reduction, expansion of economic opportunities, and advances in sustainability initiatives in the U.S. and throughout the world.

“When the board met Don, his passion, purpose and authenticity were abundantly clear and magnetic,” said Peter Benedict II, board chair. “That is the kind of leader that we, and the world, need now.”



F&ES Introduces

# ALUMNIFIRE

A grassroots networking community  
launched by F&ES alumni in September of 2018.  
**ARE YOU IN?**

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around the globe and across the decades.  
Jobs/parties/mentoring — *all on one site!*

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- Sign up for F&ES Alumnifire, the new online F&ES alumni and student community!
- You can use your LinkedIn or Facebook info to set up your profile — no need to create a separate username and login.





### Promoting a New Conversation on Climate Change: The Human Story

We know about the politics of climate change. We also know the economic story, the technology story, and the industry story, Nathaniel Rich, writer-at-large for *The New York Times Magazine*, told a Yale audience this fall. “Those are all critical to understanding how we got here,” Rich said. “But what about the human story?”

In August, the magazine published a special issue dedicated exclusively to climate change. Through photography and reporting, the issue, “Losing Earth,” aimed to spark a new conversation about climate change — one that transcends the daily media cycle in which today’s news is replaced by something else tomorrow.

On Sept. 10, the Yale Program on Climate Change Communication (YPCCC) and the Pulitzer Center on Crisis Reporting hosted a discussion with key contributors to the issue: Rich, photographer George Steinmetz, and Jon Sawyer, founding director of the Pulitzer Center. Anthony Leiserowitz, director of the YPCCC, moderated the event.

### Energy, Identity, and Rural America

Although the U.S. economy still relies heavily on fossil fuels — and the Trump administration aims to revitalize, among other sources, a languishing coal sector — many energy experts insist that market forces will increasingly make a transition to renewables inevitable.

In rural communities the effects of this transition will be deep and significant, says Justin Farrell, an assistant professor of sociology at F&ES.

Farrell recently received a \$400,000 CAREER grant from the National Science Foundation to study these impacts. During a five-year study, he will examine the economic and social impacts of this transition in places like Wyoming, where much of the nation’s coal and natural gas is extracted — and where the production of these

traditional energy sources is a defining part of the regional identity.

“There’s so much optimism about new energy around the U.S., but many Americans don’t realize that it will come at a cost for a lot of

*“There’s so much optimism about new energy around the U.S., but many Americans don’t realize that it will come at a cost for a lot of people.”*

people,” he said. “Obviously it’s important that we rapidly move to new forms of energy, but when you’re talking about entire communities changing their identity it’s really difficult.”

For the study, he plans to use social network analysis to better understand the relationships between people in rural communities — and

to spend long stretches of time in the field, interviewing individuals associated with all parts of the energy sector. He’ll analyze historic documents and articles to determine how these issues have evolved over time.

He will also examine how political affiliations help frame beliefs on energy choices and policies.

“It’s not as straightforward as just economics or the implications of learning new job skills,” he said.

“It’s a shift in a way of life and, really, a way of viewing the world. It’s deeply tied up in identity, about how people find meaning in their lives — and how, in many cases, these identities go back over generations.”

### A Forester’s Dozen

Liza Comita has had a busy year. The assistant professor of tropical forest ecology has published 11 articles in 2018 — with one more on the way — focused primarily on how “natural enemies” affect biodiversity in Panama’s tropical forests. In a particularly important breakthrough published in *Ecology Letters*, Comita partnered with Simon Stump, a postdoctoral associate and theoretical ecologist, and identified large disparities in how different species are susceptible to natural enemies. Using a theoretical model, the team disputed a major ecological hypothesis by suggesting these

disparities can create a competitive advantage for some species that may make communities less stable rather than more stable.

Through field research and data analysis, F&ES students and postdocs contributed to nearly every article Comita published this year. Comita, who received an award from Yale in 2016 for her postdoctoral mentorship in STEM fields, says mentoring researchers who are just starting their careers is “a natural extension” of her work. “By helping train the next generation, my impact on the field will be much larger.”

### Uncommon Collaborations

F&ES faculty members Xuhui Lee, Justin Farrell, and Shimon Anisfeld are part of research teams that were named winners of the Leitner Awards for Uncommon Environmental Collaborations, a grant fund that promotes collaborations for environmental teaching and research across Yale’s graduate and professional schools. Lee and Farrell will lead a project that uses thermometers mounted on bicycles to identify heat islands in New Haven’s urban landscape, which can exacerbate the effects of climate change and urbanization. Anisfeld and his team will be developing an interdisciplinary course on urban sanitation, which will include an immersive research trip to Lima, Peru.





### Leadership for a Healthier New Haven

Every year, about 257 million gallons of polluted stormwater flow into New Haven's surface waterways when heavy rains overwhelm the city's sewer system. To help curb the environmental threat, the F&ES-based Urban Resources Initiative has helped build nearly 100 "bioswales" across the city. A bioswale is a planted area engineered to capture and infiltrate stormwater from impervious surfaces. These landscaped areas, which capture 56% of stormwater runoff before it reaches the sewers, make Yale's home city more resilient and serve as an example of urban leadership. The project, which is done in collaboration with several city organizations, was awarded the 2018 Roy Family Award for Environmental Partnership from Harvard's John F. Kennedy School of Government.



### F&ES Impacts Climate Talks

At the recent United Nations Climate Change Conference in Bangkok, Thailand, F&ES was well represented by students and alumni — including Paula Chamas '19 M.E.M. (left), Maggie Yao '19 M.E.M. (center), and Aaron Feng '20 M.E.M. — who played an active part in critical negotiations on how to effectively implement the Paris Climate Change Agreement.

### F&ES Online Certificate Programs

In 2019, F&ES will introduce two online certificate programs. In "Tropical Forest Landscapes: Conservation, Restoration and Sustainable Use," a one-year program developed by the Environmental Leadership and Training Initiative, participants will be able to implement, and monitor effective conservation and restoration initiatives. "Financing and Deploying Clean Energy," developed by the Yale Center for Business and the Environment, will aim to accelerate the uptake of clean energy by building capacity in the workforce in the areas of policy, finance, and technology. For more information visit [environment.yale.edu/online-ed](http://environment.yale.edu/online-ed)

### Extending the Value of Remote Sensing

When a 2015 earthquake devastated parts of Nepal, tens of thousands of landslides buried whole villages in mud and rock, killing more than 9,000 people and destroying more than a half-million homes.

For Karen Seto, the Frederick C. Hixon Professor of Geography and Urbanization Science at F&ES, the disaster revealed the dearth of useful data about how urbanization was reshaping the landscape in the Himalayan region — and about the increasing vulnerability of these mountainous communities to earthquakes, landslides, fires, and floods. Over the past two years, she has used satellite imagery to examine

the links between urban growth, disasters, and vulnerability.

A new interdisciplinary collaboration between Seto and Eli Fenichel, an associate professor of ecosystem management and bioeconomics, will build on this research. With a \$100,000 award from Resources for the Future, they will evaluate the value of remote sensing products for allocating disaster relief resources in places like Nepal — and throughout the world.

"In 2015 we had this tragedy where if we knew where people were located we might have been able to save more lives," Seto said. "What we'd like to do is use the information we're

able to collect through remote sensing to better understand where people are building and where roads are located, to better estimate just how reachable they would be in a disaster, whether there are passable roads, and how long it would take to reach them."

Added Fenichel, principal investigator of the new study: "If decision-makers had the information from Karen's research at their fingertips after the earthquakes hit, what could have been done differently? And how can we parse that information? That's the real value of information and science — and one that is of first order importance to policy-makers."





VIVIAN BRECKENRIDGE

# ‘I’m bringing all this back to the kids’

BY KEVIN DENNEHY

As he walked across the campus of Columbia University one spring several years ago, A.J. Hudson '19 M.E.Sc. thought he had an idea where life was leading him. He'd been accepted into a doctoral program at Harvard, which looked like a pretty nice option, but was also weighing a career in consulting.

Then he bumped into someone from Teach for America who invited him to write a letter to a teacher who'd changed his life. Hudson's mind immediately returned to a fifth-grade classroom in Indianapolis, where a teacher saw him as more than a "class clown."

Hudson was happy to share a three-page letter with that teacher. But in a sudden change that surprised even him, within a few days Hudson was swapping his spot at Harvard for a teaching job at a middle school in Crown Heights, Brooklyn.

"I didn't realize what a nerd I was until I got in front of a group of eighth-graders and found that I loved teaching them about the environment," he remembers. "I said to myself, 'Oh crap, educating and teaching people about this stuff is my calling.'"

"When those kids truly understood the problems and then started coming up with ideas about how to fix global warming? I got chills. That's when I knew I wasn't going to begin pursuing my Ph.D. when those two years were up."

After a few years in the classroom, Hudson did end up pursuing a post-graduate degree, after all. He decided to pursue a Master of Environmental Science degree because he wanted to better understand the natural world he was teaching about. At Yale, he saw a chance to learn a lot — and to get his "boots on the ground."

Since arriving at F&ES, he has studied forest ecology in Panama and conducted summer research in Ecuador. He's traveled to Wyoming to talk with westerners about environmental politics and helped lead orientation for new Yale students in the streets of New Haven.

But he also knows where he wants this journey to lead: He wants to get back to those students.

"I'm hoping to bring everything I learn and all the opportunities I'm being granted back to the kids in the city," he said. "If I spend time getting to see these forests that have been destroyed and learning how to bring them back, for example, then I can take that and, in measurable and meaningful ways, bring it back to classrooms."

"Whether it's through teaching, or developing curriculum, or through pictures or books, or whatever else, I want to get all of this in front of children."

After a couple of years in Crown Heights, Hudson joined his vice principal who was opening a new school and asked Hudson to be his founding science director.

The challenge was exciting, but daunting. Many children simply didn't find environmental issues interesting or relevant. Hudson could relate; as a young person, the environment was an abstraction to him, too. So if the students weren't thinking much about the natural world, Hudson would bring the natural world to them. Or, more to the point, he convinced them that it had always been right there, even in the congested streets of Brooklyn.

When he taught about forest succession, for instance, he asked students to contemplate what the city would look like if humans disappeared, urging them to look for signs of succession in their own neighborhoods — trees reclaiming abandoned lots, plants bursting through sidewalk cracks.

"It was like they lived on a space station and they were looking at earth from a vast distance," he says. "My job was to close that distance a little bit. To bring them closer to the environment. To make it matter to them."

"I always tell people that the genius who's going to solve climate change is sitting in a crowded classroom in Brooklyn, in a school that doesn't offer her environmental science classes and that's just forcing her to take AP math and English classes," he said. "We're limiting our ability to save the future because we're shortening what our children are capable of."







# Crowdfunding Local Action

BY KEVIN DENNEHY

In 2007, the U.S. Forest Service published a survey of the grassroots organizations that managed green spaces in New York City; about 75 percent were run by volunteers, and about half had an annual budget of less than \$1,000. At the time, three recent F&ES graduates living in New York were contemplating business ideas that could make a difference at the community level. Erin Barnes '07 M.E.M., Brandon Whitney '07 M.E.Sc., and Cassie Flynn '07 M.E.M. settled on a social venture called ioby, which would provide funding, training, and other guidance in support of such under-funded projects and groups.

A decade later ioby — which stands for “In Our Backyards” — is operating in five U.S. cities. At any given time it supports up to 500 projects and, so far, has helped nearly 1,700 projects reach full funding, amassing more than \$5 million in public donations.

Barnes, who still runs ioby with Whitney, was recently named one of 20 inaugural Obama Fellows for her contributions to community resilience and was nominated for a Pritzker Emerging Environmental Genius Award. In a recent interview, she described the vision for ioby and how it empowers local residents to become civic leaders.

## *How was ioby born?*

The three of us were bouncing around ideas and had different frameworks for understanding environmental work but at the core we all felt there was an overlooked and underfunded population that was really focused on the important parts of civic life. We realized that institutional philanthropy is structurally designed to support larger nonprofit efforts, whereas there is a lack of resources and attention going to the grassroots groups that tie together and support the civic fabric of communities in environmental work, but also in racial justice work, economic justice, and so many other ways. We founded ioby on this idea of allowing residents to reinvest in their own communities and to lead change. It's a place where people could raise money, recruit volunteers, and access other sorts of technical assistance.

We modeled it after kiva.org and donorschoose.org, the world's first crowdfunding platforms. But while kiva.org enables a person to, say, invest \$100 to help an entrepreneur in Guatemala, we asked, “What if people were able to make the same kinds of contributions in their own backyards?”

## *When did you know you were on to something?*

We were still a pilot project in New York from about 2010 to 2012. There was just this huge swell of enthusiasm. And it wasn't just people who had funding needs. We heard from people who wanted to volunteer, people who wanted to give back, people who wanted to do something meaningful in their own communities. A lot of people want to donate to causes that are meaningful to them, but it's often difficult to imagine that a \$25 donation will make a difference to a huge organization. But if an organization needs to raise \$5,000 to repair a basketball court in a park, a \$100 donation is a meaningful contribution. And after it's done they can actually see — with their own eyes — the impact.

We started getting requests from across the country for our services, and so we decided to expand in 2012. We now have organizers on the ground in Memphis, Detroit, Cleveland, and Pittsburgh

## *How has the mission of ioby changed over the years?*

After Superstorm Sandy, we took a hard look at all the groups that ioby was supporting and found that those best able to support their neighborhoods in recovery weren't necessarily the ones doing direct environmental or sustainability work. We concluded that resilience comes from a tight civic and social fabric. We made a strategic decision to support not just ‘environmental’ projects, but neighborhood-based projects of any kind.

One area where we have succeeded is explaining to people what it means to be a civic leader, to step up and lead. A lot of people just don't think they're the right person to do it, but in fact they usually *are*. They're the ones who have identified the problems, come up with the solutions, and who really know all the ways their communities can be successful. A big part of what we do is encouraging people to take that big, scary step to becoming civic leaders themselves.

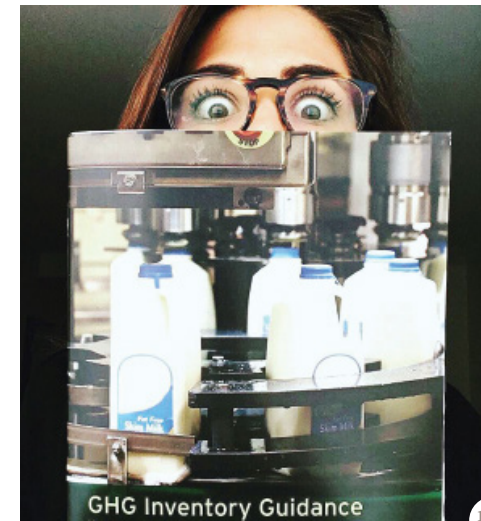


# School's In for Summer

F&ES students were busy last summer, interning or conducting research in 34 countries and in states across the U.S. Here are a few of their dispatches from the road.



1 **Sarah Omusula** conducted research on human-wildlife conflict mitigation in Kenya by analyzing and comparing compensation schemes to enhance co-existence between wildlife and local communities. 2 **Sofia Caycedo** worked for the Sustainable Development cluster at UNDP Panama to support the countries of Latin America and the Caribbean with the implementation of the Sustainable Development Goals through MAPS (Mainstreaming, Acceleration and Policy support). 3 **Jillian Howell** interned with the Spokane Riverkeeper researching salmon reintroduction and recovery, within the context of the renegotiation of the Columbia River Treaty between the U.S. and Canada. 4 In Hangzhou, China, **Tina Huang** studied the effects of bike-sharing on urban public spaces. 5 As a law clerk at Our Children's Trust, **Paul Rink** assisted the legal representatives of 21 youth plaintiffs in their fight against the U.S. government for a climate recovery plan. 6 **Max Potthoff** researched a variety of issues related to pesticide application and compliance for the Environmental Protection Agency, under the Federal Insecticide and Rodenticide Act (FIFRA). 7 In South Africa, **Leandro Vigna** worked as an architect for the Green Building Council and **Andy Lee** studied predator reintroduction in wildlife reserves. 8 **Ali Golden** interned at Thermo Fisher Scientific, working to expand the company's glove and single-use garment recycling programs in their manufacturing facilities. 9 **Ki'ila Salas** measured endangered mahogany trees in Belize to analyze which treatments work best for their long-term growth and survival. 10 **Sara Santiago** and **Melanie Jones** visited farms across Cuba by horseback, conducting interviews on agro-ecology and food resilience. 11 **Abby Snyder** wrote a Greenhouse Gas Inventory Guidance report for dairy producers that was approved by the USDA. 12 **Emma Gildesgame** created mapping tools which will allow National Parks Conservation Association staff to build custom maps to support their work and tell the spatial story of their parks. 13 **Luke Elder** interned at Tesla, where he calculated their first greenhouse gas inventory and contributed to their first sustainability report. 14 **Thomas Launer** helped park rangers in Rwanda draft strategies to protect endangered mountain gorillas and restore the degraded mountain forests outside Volcanoes National Park.

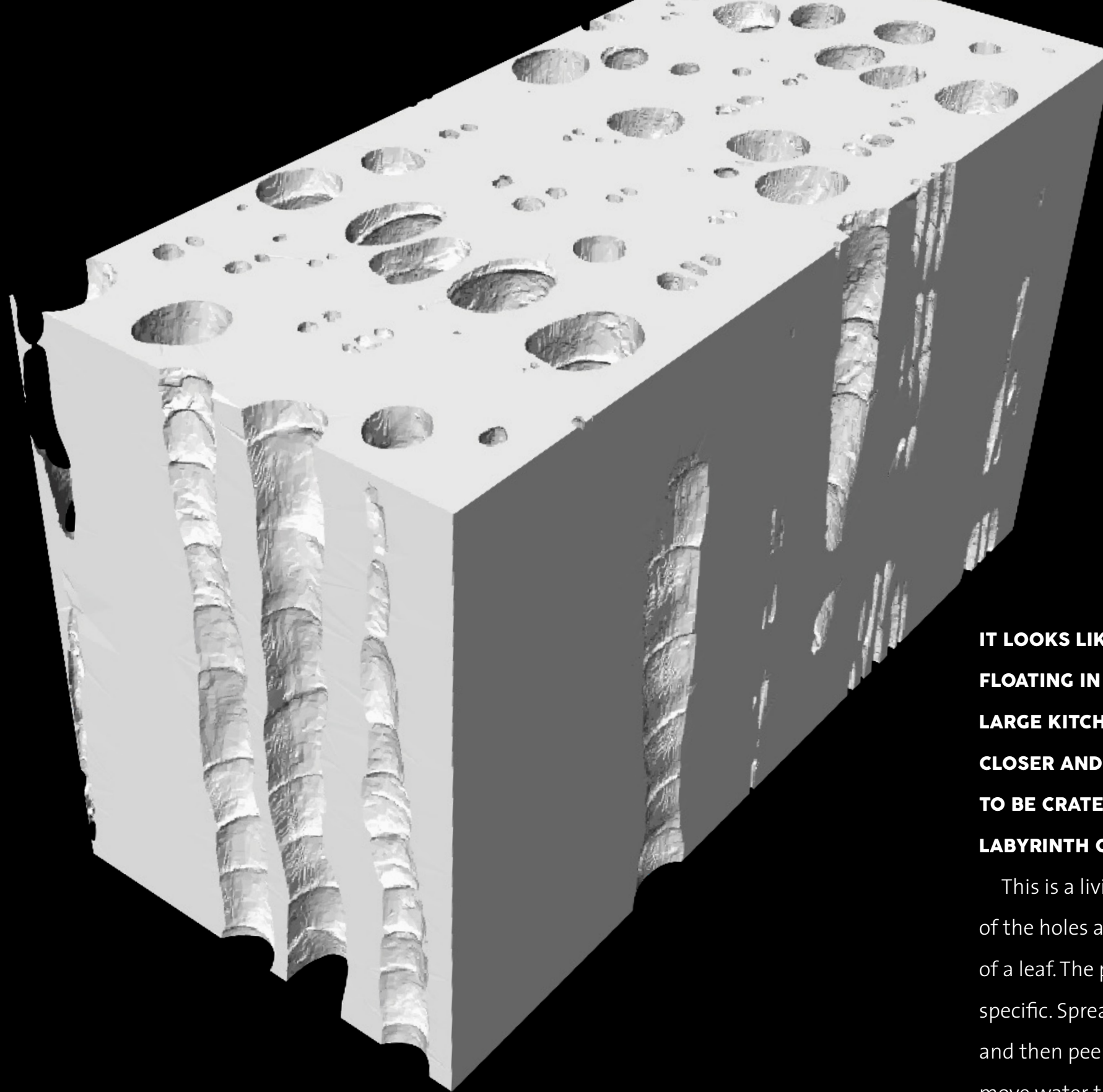




WANT TO  
SEE THE  
FUTURE  
OF TREES?

# LOOK INSIDE THE PIPES

BY KEVIN DENNEHY



**IT LOOKS LIKE A CHUNK OF SWISS CHEESE, FLOATING IN BLACK SPACE. OR MAYBE A LARGE KITCHEN SPONGE. INCH A LITTLE CLOSER AND WHAT AT FIRST HAD APPEARED TO BE CRATERS START TO HINT AT A DEEP LABYRINTH OF TWISTING CAVES.**

This is a living organism. Step inside one of the holes and enter the complex plumbing of a leaf. The petiole of a white ash leaf, to be specific. Spread your arms to widen the scale, and then peer up into the xylem vessels that move water through the leaf.

COURTESY OF BRODERSEN LAB, YALE UNIVERSITY



“Now I’m standing inside one of those tiny vessels,” says Jay Wason, who is guiding this tour with the help of virtual reality goggles and who, until recently, was a postdoctoral fellow with Craig Brodersen, an assistant professor at the Yale School of Forestry & Environmental Studies (F&ES).

“Look behind me and you’ll see a giant hole. The water would flow through here, past where I am and across this ridged area, up to the leaf stalk.”

“By now you’ve shrunk yourself down to probably 1 or 2 microns,” he adds. “It starts to get a little mind-blowing.”

This virtual experience, which is now part of Brodersen’s teaching, is a product of an emerging field of research that uses 3D imaging and other technologies to better understand and visualize the inner workings of plants and trees.

The ability to wander through the hydraulic system of plants, at least virtually, and to peer into pipes that are, in reality, thinner than a human hair, makes these complex plant systems easier to grasp, says Brodersen, an assistant professor of plant physiological ecology and one of the global pioneers of this research.

But it’s not just students who benefit. These technologies, which largely borrow from the medical imaging field, are altering the way scientists understand how these vital organisms function. And, critically, they’re providing important insights into how changing global conditions might disrupt their ability to perform in the future — and how they might affect the capacity of the world’s forests to store carbon.

“Trees are all around us. We all walk by trees every day but can’t appreciate all that’s going on inside them,” Brodersen says. “And there’s a lot of amazing biology and anatomy that people just don’t have access to. So we’re trying to break down some of those barriers for appreciation and get it into the hands of as many people as possible.

“These technologies are allowing us to do that in ways never before possible.”

For thousands of years, humans have speculated about the internal structures and systems that allow plants to grow. But it wasn’t until the late 1500s that, with the introduction of the compound microscope, human eyes were finally able to peek into this secret world.

In the late 17th century, the English plant anatomist Nehemiah Grew and Italian botanist Marcello Malpighi offered the first conceptual illustrations of the three-dimensional nature of living organisms. Despite technological limitations, Grew in particular made some of the earliest attempts to represent the internal systems of plants in 3D, illustrating the complexity of their internal organization.

The introduction of photography and microanatomy techniques made it easier for scientists to represent the xylem networks through which plants transport water. But by and large, many of the illustrations found in contemporary textbooks are consistent with what was available in the late 17th century.

“One of the main limitations has been that we were trying to look at these 3D structures with two-dimensional tools,” says Brodersen.

As scientists now understand, the vascular system of the typical tree species isn’t comprised of a few straight pipes that move water from the roots to the leaves.

It’s more like thousands of strands of spaghetti, twisting around each other and moving in every direction.

To understand these networks, you really have to look at them in three dimensions.

In the past, a scientist wanting to create a 3D perspective had to cut a plant specimen into hundreds of cross sections, which had to be dehydrated, placed under a microscope, and manually reassembled to capture, to the greatest extent possible, the complexity of the organization. That procedure, which is still used widely, can be extremely time-consuming and the sample is vulnerable to damage at any point in the process.

Over the past decade, Brodersen and a group of colleagues have been using high-resolution X-ray imaging and other non-invasive imaging tools in order to better observe these vascular systems and other components of plants.

The research team prepares tiny fragments from root, leaf, and flower specimens, and brings them to the Lawrence Berkeley National Laboratory in California for processing. Using the laboratory’s Advanced Light Source facility, they rotate these samples in an X-ray beam, which produces hundreds of 2D images that are then reconstructed to produce rich, 3D data sets.

Typically the process — known as micro-computed tomography, or micro-CT — takes about twenty minutes.

Brodersen’s team developed semi-automated software that can process the enormous troves of data produced by each scan — about 3 to 4 terabytes in a typical session — to produce imagery they can analyze.



Jay Wason, a former postdoctoral fellow with the Brodersen Lab, demonstrates the virtual reality experience using a headset. (Wason is now an assistant professor at the University of Maine.) The technology also works with a smartphone when paired with an inexpensive viewer, like a Google Cardboard. Craig Brodersen uses the smartphone-based viewer.



The data produced by this process are allowing Brodersen and other members of his F&ES lab to confirm long-held theories on plant processes and explore questions about how global changes could affect different species.

They're finding that plants are as diverse on the inside, in terms of appearance and structure, as they are on the outside.

For example, they recently produced the first 3D images of a spinach leaf; they looked nothing like the previously published illustrations of the plant. For one thing, the structure is more complex than scientists had imagined, with a maze of air space passageways that could have important implications in terms of how CO<sub>2</sub> moves through the plant during photosynthesis and how water vapor escapes.

In a long-term study, they are evaluating how a changing climate — and an increase in extreme weather events — might affect the physiology of four hardwood species common in the northeastern United States. Over time, they will compare how the trees' vascular systems respond to drier conditions, and evaluate whether there will be a tipping point beyond which the species wouldn't be able to survive.

"There are certainly other groups around the U.S. and the world that are doing similar projects," Brodersen said. "But the advantage we have is that we've reached the point where the instrumentation and image processing we've developed is



Craig Brodersen, left, and students remove needles from a white pine at the research lab at Yale-Myers Forest. A scan of a pine needle can be seen in the inset at left.

sophisticated enough that we can do additional computer modeling exercises to simulate the types of drought that haven't yet occurred in New England, but are on the horizon."

In another project, they're examining the internal anatomy of conifers, down to the molecular level. In theoretical models, for instance, they have illustrated what Brodersen calls "the torturous path" that a single CO<sub>2</sub> molecule must travel to get where it needs to go in the needle.

It's not just cool, "Magic School Bus" stuff. It's also offering insights into why some species thrive and, again, how that could change over time.

"For example, you have a species like ponderosa pine, which grows from Mexico to British Columbia, whereas other species, like coast redwoods, are constrained to a small area," Brodersen said. "What is it about that particular species and its needles or its vascular system that allows it to be so competitive in so many different habitats? Certainly part of it is demographics and historical changes that have taken place over thousands of years. But there's also some pretty interesting physiology and

anatomy going on that allows some species to be really widespread and competitive."

On occasion, the process itself provokes questions that were never previously considered, opening up new doors of research, said Adam Roddy, a postdoctoral associate in the Brodersen Lab.

"Sometimes you see things in these 3D images that give you all these other ideas about how plants work," said Roddy, who studies how plant physiological function influences survival and performance. "Quickly exploring structures, I often find myself saying, 'Wow, that's a weird structure. I don't know what I would have expected there, but I'm surprised that that's right there.' Some of it is just alpha discovery in a sense, but then, for me, it has led to some more clear hypothesis testing."

One unexpected benefit, for instance, has been the ability to infer the chemical composition of plant structures simply by analyzing how different compounds absorb and respond to X-ray energy during the scanning process. The 3D imaging can also reveal where compounds, like carbohydrates, are stored in a plant — information that reveals important insights into how the plant functions.

"It's kind of like archaeology," Roddy said.

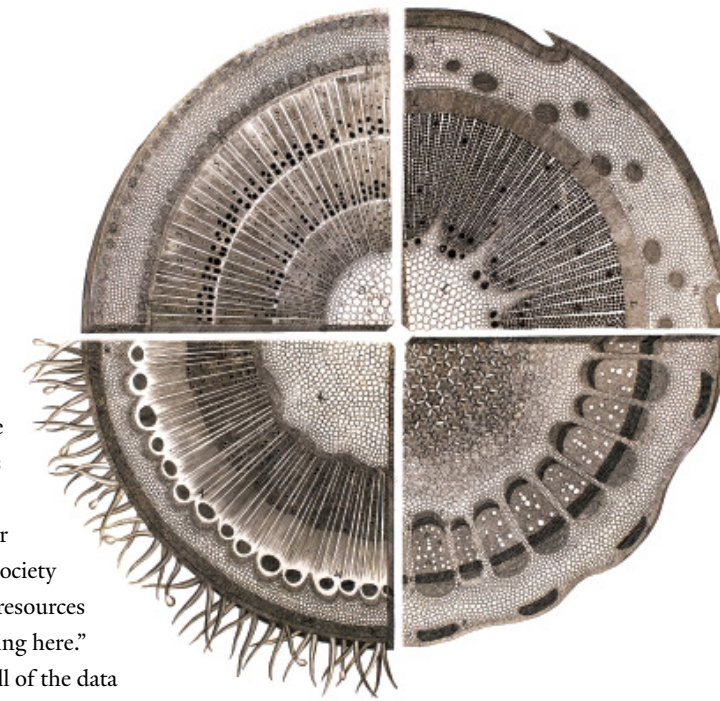
"Archaeologists go into a site and find out where food was stored or where there was a cattle pen. They have a better understanding of how that society worked based on where the resources were stored. It's the same thing here."

Over the past few years, all of the data collected by Brodersen's team have been gathered into a massive repository — which now includes more than 200 species — that will be available to answer other scientific questions now and in the future.

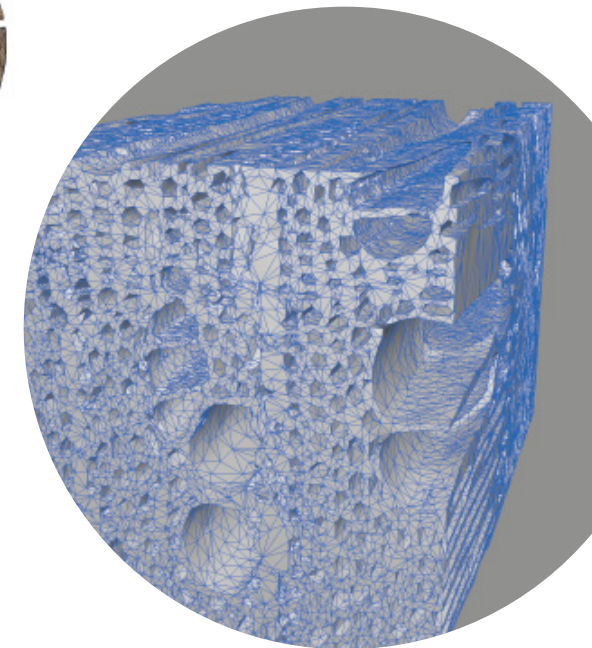
They are also making much of the data available to any teachers and professors who want to integrate the information into their curricula for courses in plant biology or physiology. With funding from the National Science Foundation and the Yale Center for Teaching and Learning, for instance, they've developed a website featuring the 3D models for the four tree species being monitored in the long-term New England study, as well as teaching resources for lesson planning. In schools with 3D printers, teachers will be able to download the models and create their own plastic models.

Also, an app on the site enables students to access the virtual reality experience without the benefit of a high-cost VR headset. Rather, they can experience their own tour of the inside of plants as long as they have a smartphone and an inexpensive viewer, such as Google Cardboard.

"The idea is to get these into the hands of as many people as we can," Brodersen said. "For me, I'm a very visual, hands-on learner.



At left, a composite of four illustrations from Nehemiah Grew's 1682 book, *The Anatomy of Plants*. Below, a 3D image of petiole of a white ash leaf.



I've got to put my hands on something to really learn it. And I know there are a lot of students who are the same."

For some Yale students who have taken the virtual tour as part of the course, Plant Ecophysiology, that has been the case. "Being able to look at something automatically changes the way you understand it," said Phoebe Mankiewicz, a first-year Ph.D. student. "It's one thing to cut it into slivers and try to determine how they fit together, but it's another thing entirely to have a model that you can look at and make inferences from."

"It allows you to see the cell anatomy you would in a two-dimensional cross-section. With this technology, you can turn the image and see how the different cell shapes fit together and interact. Rather than seeing just flat circles, you see oblong networks of tunnels."

But for these students, who are studying not just plants but how they perform in larger ecosystem contexts, experiencing organisms at the microscopic level represents just one scale. On a recent Friday, a group of Brodersen's students traveled to Yale-Myers Forest, where they spent a few hours collecting data in order to calculate the biomass and carbon sequestration

capacity of a stand of white pines.

To help make these calculations, they cut down a 70-foot tree and began disassembling it piece by piece; they cut thin cross-section "cookies" at every meter, clipped every branch for weighing, and removed and weighed the needles from the top branch of each leader.

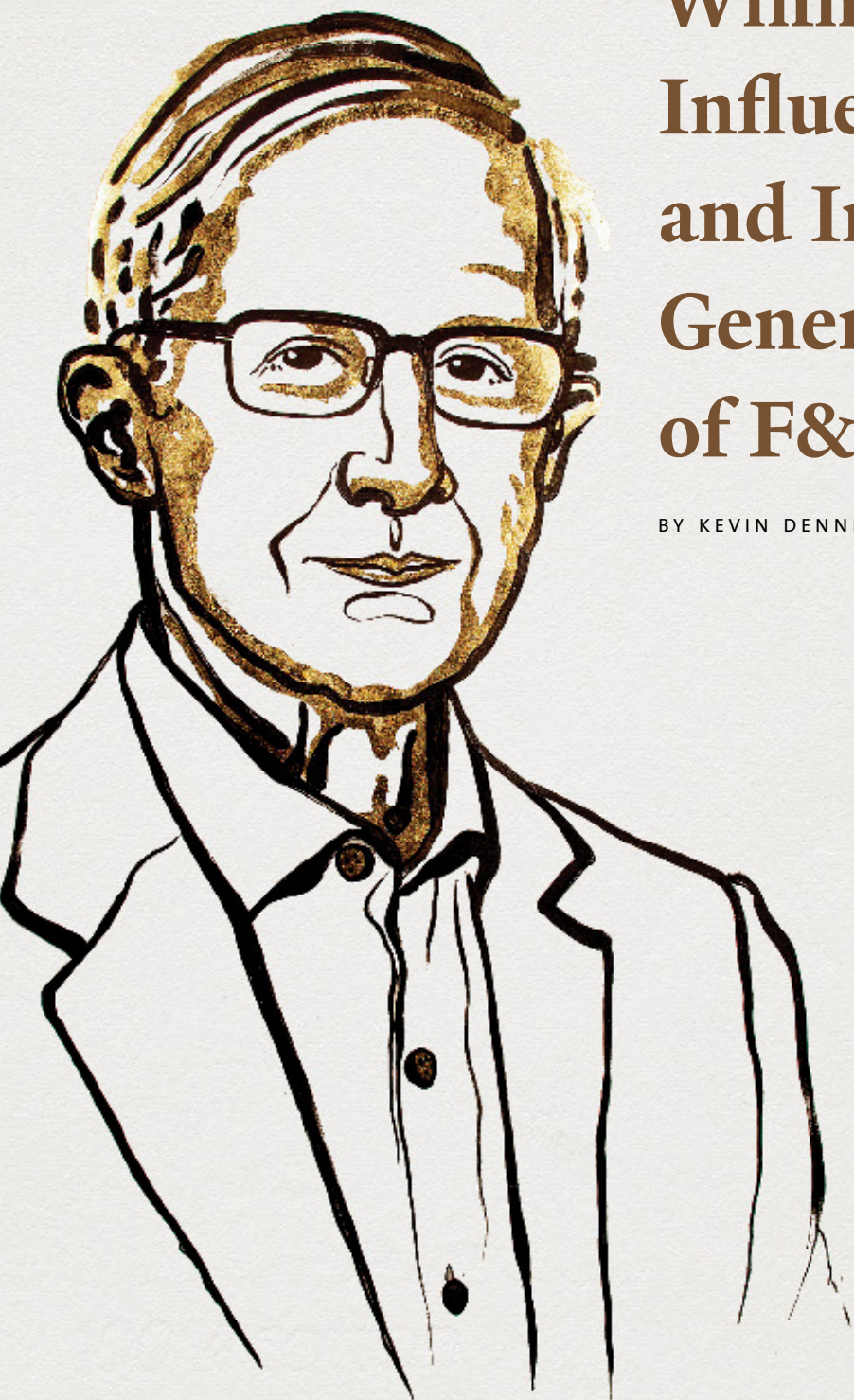
"Being able to scale up from the cellular level to the level of the entire tree, and then, ideally, to the entire forest is very valuable," Brodersen said. "It's really the only way to see how these different parts of the plant are integrated, where the plant spends its resources, and how the larger forest is pulling carbon from the atmosphere."

"These are things you just can't get from a two-dimensional image in a microscope or a textbook. They'll never look at trees the same way again."



# Nobel Prize Winner Has Influenced and Inspired Generations of F&ESers

BY KEVIN DENNEHY



**In the mid-1970s very few scientists were thinking seriously about climate change. And even fewer were worried about how it might affect the global economy in the coming decades.**

But for William Nordhaus, a Yale Sterling Professor in Economics and professor at F&ES — recipient of the 2018 Nobel Prize in Economic Sciences — the long-term fate of the planet was very much on his mind.

Robert Mendelsohn remembers this well. At the time, he was a young Ph.D. student in

economics at Yale, and Nordhaus was his advisor. Mendelsohn, who is now the Edwin Weyerhaeuser Davis Professor of Forest Policy and Professor of Economics at F&ES, remembers his mentor advising him to study the intersection of economics and the environment. But as for tackling an issue so uncertain as climate change? At the time, Mendelsohn admits, it seemed a little risky.

Before long, however, it became clear that William Nordhaus' research was ahead of its time. Over the next four decades, Mendelsohn says, it would change our understanding of what is now understood as a global threat — and how society might avoid the worst outcomes.

“Bill Nordhaus is the father of climate change economics,” said Mendelsohn, who would go on to collaborate with Nordhaus on important climate research, including about the potential impacts on agriculture.

“He organized this research for the first time, and pretty much everything else that has come after is a daughter product of that work.”

Nordhaus, who shared the Nobel Prize with Paul Romer, a professor of economics at New York University, was honored for “integrating climate change into long-run macroeconomic analysis.”

Since the 1970s, Nordhaus has developed influential models of the interplay between climate change and the economy. His DICE and RICE models, lauded for their elegance and simplicity in illustrating the link between economic growth and the planet, are still widely used in climate research and policy.

At F&ES, where he holds a secondary appointment, his research and teaching have influenced and inspired generations of scholars.

For three decades, he has worked with Mendelsohn on climate-related research. Their 1994 study on the potential climate impacts on agriculture offered early evidence that the changes would vary from region to region, with warmer regions paying the biggest price.



William Nordhaus addresses the press on Oct. 8, 2018

Six years ago, they published an influential study on how different sectors and industries affect the global climate.

“He has just pushed the envelope on so many fronts,” Mendelsohn says. “He’s been able to bring the science into an economic model in order to anticipate what the damages caused by climate change might look like — and to build a theoretical framework that helps us make better decisions into the future.” Earlier this year, Nordhaus co-authored a paper

with Kenneth Gillingham, an associate professor of environmental and energy economics at F&ES, which concluded that potential for high global economic growth — and, as a consequence, an even steeper rise in carbon emissions — could be much greater than previously known. In their collaboration, they’ve tried to find a way to integrate that uncertainty into a greater framework which quantifies uncertainty in future outcomes, Gillingham says.

“The hallmark of Bill’s work is the transparency and the intuition that goes into it,” he said. “He is just amazing at seeing the essence of a problem and clarifying that in a transparent way to the reader.”

And for all his acclaim as a researcher, colleagues say Nordhaus still loves working with students. Last year he and Mendelsohn co-taught a seminar course in which F&ES and economics students were asked to reproduce prominent climate-related studies. In doing so, they were able to evaluate the strength of the outcomes, identify assumptions that influenced conclusions, and reevaluate whether different conclusions might have been reached.

One of those students was Jonghyun Yoo ’16 M.E.Sc., a Ph.D. candidate at F&ES. Yoo had become familiar with Nordhaus’ economics modeling years earlier, when he was doing his own environmental economics work in South Korea; in fact, it’s one of the reasons he came to Yale. The course, he said, allowed him to not only examine the assumptions and personal considerations that sometimes inform science, but to receive feedback from leading scholars in the field.

But for Yoo that feedback wasn’t limited to class. He was honored — even a little surprised — when Nordhaus agreed, at Mendelsohn’s invitation, to serve on Yoo’s Ph.D. committee.

In April, on the morning that Yoo was to make his oral presentation to become a Ph.D. candidate, heavy rains pounded New Haven; Yoo didn’t

## WITH CARBON CHARGE YALE BECOMES A ‘LIVING LAB’

As a longtime champion for carbon pricing as a solution to climate change, William Nordhaus helped inspire what has become the Yale Carbon Charge Project.

In fact, it was during a 2014 Earth Day panel event, organized by Daniel Esty, Hillhouse Professor of Environmental Law and Policy, that the initiative was born. During the event, an F&ES student asked the panel, which included Nordhaus, about Yale’s role in reducing carbon emissions. In an offhand comment, Nordhaus suggested, “Yale could implement an internal carbon tax.”

The idea gained traction. Within a year Yale President Peter Salovey appointed a task force, chaired by Nordhaus, to examine whether a carbon tax might help the university achieve its sustainability goals. Then, after a six-month pilot program, the university introduced an internal carbon-pricing initiative that now incentivizes lower energy consumption in 250 buildings across Yale.

The project is directed by F&ES alum Casey Pickett.

In addition to changing energy choices on campus, the Yale Carbon Charge Project has spawned numerous research projects, making the university “a living lab” on carbon pricing.

The project also inspired a case study, through the F&ES’s Case Study Integration Initiative, that is available for use in undergraduate and graduate level courses that cover environmental economics and policy, corporate social responsibility, and climate change mitigation.

expect Nordhaus, who typically gets around on campus on foot, to walk all the way up Prospect Street in the middle of the spring storm. But just as Yoo was about to begin his presentation, Nordhaus entered the seminar room, offering a comforting smile and a gentle fist-bump.

“And of course he offered much important, helpful advice,” Yoo says.



# RWANDA HAD DIFFERENT PLANS

BY JOSH ANUSEWICZ

Nearly three decades ago, a brutal war ripped Rwanda apart at the seams. Years of conflict between the Hutu and Tutsi ethnic groups came to a head in the early 1990s, culminating in one of the darkest periods in recent world history. The genocide against the Tutsis led to the slaughter of hundreds of thousands of Rwandans and the displacement of millions more. The horrific ordeal tore families and communities apart and crippled the economy, ruining the country's infrastructure.

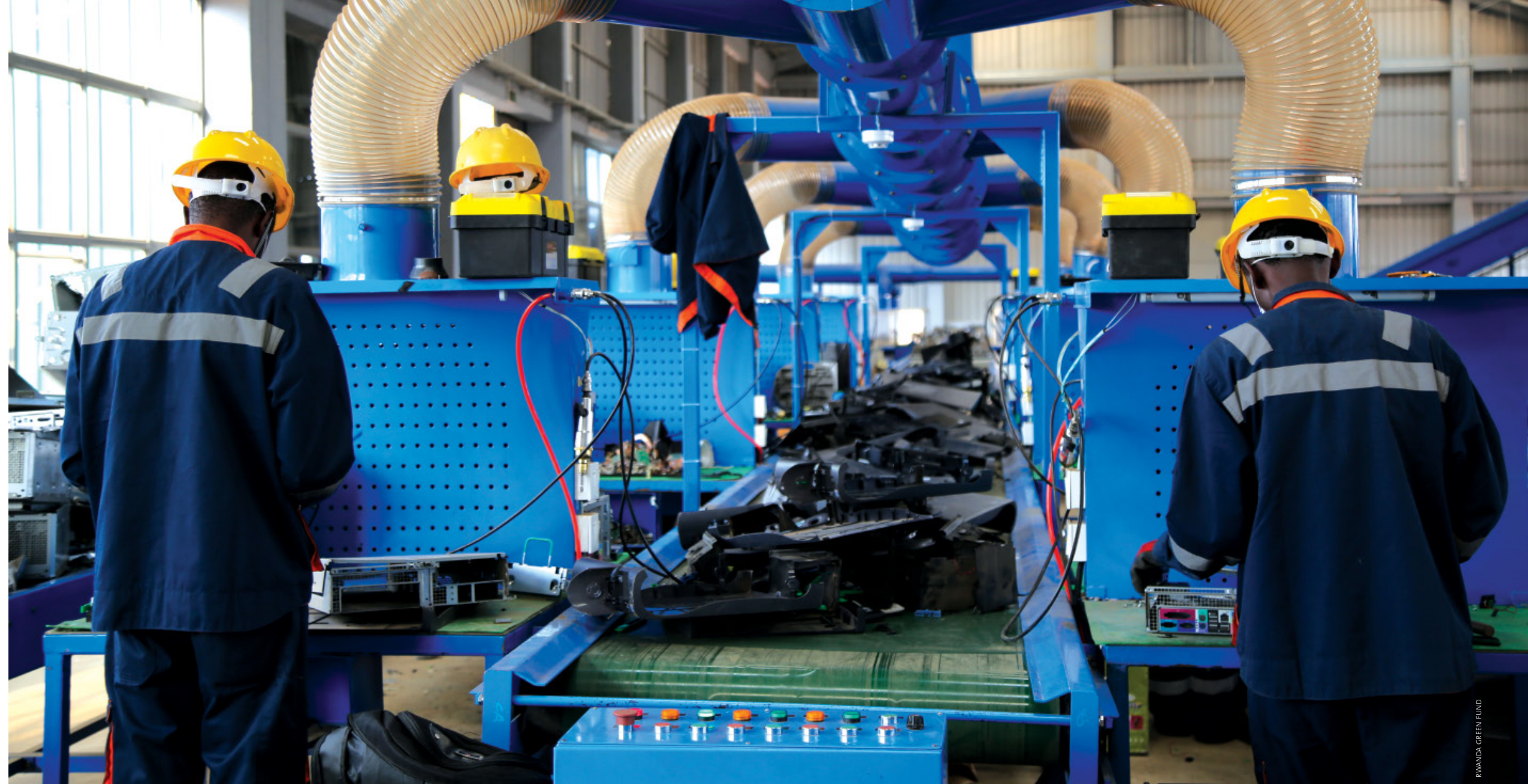
The international community looked at Rwanda, a fledgling nation formed just over 30 years prior, and saw a familiar narrative playing out; one of war and poverty on the African continent that would require constant aide to avoid becoming a failed state.

Rwanda had different plans.

According to the United Nations' publication *African Renewal*, Rwanda has one of the world's fastest growing economies, averaging 8 percent growth per year from 2004–2014. In 1994, 78 percent of Rwandans lived below the poverty line; today, that number has been cut nearly in half. The highest primary school enrollment on the continent, affordable and reliable internet service, a clean and safe capital city — all part of current-day Rwanda.

"We took control of the situation," said Parfait Gasana '18 M.E.M., a Rwandan, born a refugee in Burundi, and now an advisor to the Rwandan government. "Our leadership determined that we couldn't wait around for other countries to step in and do the work that Rwandans should have done in the first place. We could begin anew and craft something that the world would look at as an example for developing a nation.

"Today, Rwanda is providing leadership on issues of peace, security and, most importantly, environmental stewardship. When you think of sustainability in Africa, you think of Rwanda."



Rwanda opened a multi-million dollar e-waste recycling facility in 2017, aimed at properly disposing of potentially hazardous materials found in electronics.

Vincent Biruta is a jack of all trades — and he's something of a master of them, too. A trained physician, Biruta has spent the last 20 years heading Rwanda's departments of health, public works and transportation, education, and serving as the president of the Rwandan Senate for varying lengths of time. In 2014, he was appointed to his current role as Minister of Natural Resources.

He is a statesman who warrants attention. So, when he shares his views on tackling environmental challenges, they carry considerable weight.

"Containing the warming of our planet is the single most important action we can take," Biruta told an audience at the Yale School of Forestry & Environmental Studies (F&ES) in September. "This is not a choice — this is a must. Any sector, anything you do, the environment has to be taken into consideration."

Biruta visited Yale to sign a Memorandum of Understanding to formalize greater collaboration between the University and Rwanda in the areas of education and research in sustainability, environmental protection and conservation. The memorandum was also signed by Yale President Peter Salovey and F&ES Dean Indy Burke, as well

as the deans from the schools of engineering, nursing, and public health. The reciprocal Yale-Rwanda partnership will pursue opportunities for collaborative teaching and research in support of the United Nations Sustainable Development Goals, foster an exchange of resources, and create new opportunities for Yale students to study, intern, and conduct research in Rwanda.

The partnership fits well into Yale's Africa Initiative, which promotes greater collaboration between Yale and the African continent in areas of scholarship, research, and student recruitment. But while the arrangement will

provide opportunities for undergraduates and several graduate programs, the most important connections will be forged across disciplines around sustainability.

Rwanda is increasingly seen as a leader in sustainability efforts, not just in Africa but across the world. In 2008, the country banned the use of plastic bags. They also embarked on a massive reforestation initiative, aiming to increase forest cover to 30 percent of the total land area by 2020. National parks have been created and wetlands have been restored, increasing hydroelectric power. Rwanda established the Green Fund, capitalizing more than \$100 million





RWANDAN GOVERNMENT

The capital city of Kigali is considered to be one of the safest, cleanest, and most technologically advanced cities on the African continent.

USD to date to support public and private projects aimed at building a green economy, while additional funding has been obtained through accreditation from the International Green Climate Fund. And, in October 2016, the capital city of Kigali played host to the signing of a landmark amendment of the Montreal Protocol, which phases out hydrofluorocarbons, or HFCs, for next-generation technologies with a lower environmental impact.

“Rwanda is a perfect partner at this point,” said Coral Bielecki ’18 M.E.Sc., a co-coordinator for the partnership and a research assistant

for Professor Marian Chertow at the Yale F&ES Center for Industrial Ecology. “They’ve integrated the environment into all of their policies. They’re a rising star.”

Bielecki has teamed up with Gasana and Chertow for roughly two years to build this partnership with Rwanda. The wheels began turning in 2017, when Rwanda partnered with Nigeria and South Africa and launched the African Circular Economy Alliance to create a new model of sustainable development in Africa. A circular economy is one in which resources are used for as long as possible, extracting the

maximum value, then recovering as much of the materials as feasible at the end of their service life. It is a popular concept related to the interdisciplinary field of industrial ecology in which F&ES, through the Center for Industrial Ecology, is a world leader.

Under the direction of Minister Biruta, Gasana was tasked with pursuing efforts that promoted the circular economy in Rwanda. Fortunately for him, he didn’t have to go far to find Chertow, one of the world’s experts on circular economies. An F&ES team was swiftly assembled to create an assessment of what the circular economy could bring to Rwanda, impressing Biruta enough to seek out further collaboration with the School.

The seven-year partnership is still taking shape – Gasana said they’re “in the programming stage” right now. But he and Bielecki stressed the desire for this effort to be based on the values of reciprocity and cooperation, where Yale students and faculty can learn and conduct research, while Rwanda uses Yale’s resources

and knowledge to implement effective policy.

“We’re all looking beyond seven years – to what could happen 50 years from now,” said Gasana. “We want to look back at what Yale has done in Africa and see that we were part of a legacy that helped make a substantial difference in the world.”

“And even though Rwanda is a small country, they can play a big role. They may not be the biggest emitter of carbon emissions, but they suffer as much as anyone. They want to be among the players in finding a solution. They want to roll up their sleeves and get to work.”



# Reunion 2018

**Alumni and their families returned to F&ES for Reunion Weekend, October 5–7, enjoying a field trip to Yale-Myers Forest; a musical performance by Ben Cosgrove; a keynote address by Rob Klee ’99 M.E.S., ’04 J.D., ’05 Ph.D., Commissioner of the Connecticut Department of Energy and Environmental Protection; and Harvest Dinner in Sage-Bowers Hall.**





Clockwise from top left: Associate Dean Gordon Geballe congratulates Michael Jenkins; Assistant Dean Joanne DeBernardo and Dean Indy Burke flank Sarah Charlop-Powers; Alumni Association Board President Joe MacDougald '05 M.E.M. and Vice-President Tara Meyer '15 M.E.Sc. present Eleanor Sterling's award, accepted on her behalf by Alex Moore '18 Ph.D. (right).

# AWARD RECIPIENTS

## Michael Jenkins '88 M.F.

### DISTINGUISHED ALUMNUS

About thirty years ago, Michael Jenkins '88 M.F. walked into the office of a high-ranking environmental official in Papua New Guinea. And he had news that he expected would make the minister's day.



At the time Jenkins worked for the MacArthur Foundation. And, as he informed the minister that day, the foundation was prepared to spend \$5 million to help protect the island's wildly diverse, yet very vulnerable, ecosystems. The funding would support training for local leaders, capacity building for local nonprofits, and help strengthen areas designated for protection.

To his astonishment, upon hearing the news the minister simply nodded casually. Then, as Jenkins left the room, he saw two individuals carrying large briefcases enter the same office. He doesn't know what was in those briefcases, but it occurred to him that existing conservation models simply couldn't compete with the incentives of illegal logging. "It was clear that we didn't have the financial equation right," he recalls. "And until we got these values right, we were going to lose the whole game."

Over the next several years he helped develop a new approach to conservation that recognized the proper value of these natural systems — and began to place a price on it. In 1998, he founded Forest Trends, a global nonprofit that works with different stakeholders to protect vital ecosystems across the world through finance, markets, supply chains, and other incentive mechanisms.

## Eleanor Sterling '83 B.A., '93 Ph.D.

### DISTINGUISHED ALUMNA

The aye-aye — widely considered one of the most endangered primates on the planet — is notoriously difficult to study. It is nocturnal, travels long distances, and spends its life high in the trees. Eleanor Sterling '83 B.A. '93 Ph.D. spent the better part of two years doing fieldwork at night, living without electricity on an otherwise uninhabited island accompanied only by Malagasy field assistants, studying this elusive and iconic animal.



"The aye-aye was just such a flagship for conservation but it was unclear what conservation actions needed to happen in order to conserve it because there was so little known about it," said Sterling. "One of the things I was concerned about was not just talking at people about conservation, but thinking about what are the concerns of the local community members."

Those concerns began a thread that has run throughout Sterling's globetrotting career with the American Museum of Natural History in New York, where she is the Jaffe Chief Conservation Scientist at the Center for Biodiversity and Conservation. She is also an adjunct professor at Columbia University, and her work as both an academic and practitioner has combined biological conservation, scientific research, environmental education, and program administration. Along the way she has studied more than a dozen languages, and conducted more than three decades of fieldwork in Africa, Asia, Latin America, and Oceania.

## Sarah Charlop-Powers '09 M.E.M.

### PROSPECT STREET AWARD

The city of New York contains more than 5 million trees across 20,000 acres of forests and wetlands, a fact that even many New Yorkers might not realize. Sarah Charlop-Powers '09 M.E.M. is trying to change that.



"For fifty percent of people who use New York City's parks, the only interactions with nature take place in those parks," she said. "Many of us have this preconceived idea that a city park tides you over between chances to get into rural areas. For many city dwellers, those wilderness experiences just aren't happening."

"We need to reconsider the unique experiential benefits of interacting with local nature."

Charlop-Powers is the executive director and co-founder — with Bram Gunther '91 M.E.M. — of the Natural Areas Conservancy (NAC), a Manhattan-based nonprofit that works to restore and conserve New York's natural lands and to get more New Yorkers outdoors.

The NAC conducted the largest baseline assessment of the condition of natural areas of any city in the U.S., leading to the development of New York's Forest Management Framework. The 25-year plan brings all of the city's forests under a financial model that can tie ecological conditions to cost estimates, allowing for more refined goal setting and recommendations for the city's entire forest management program.





All reunion photos by Peter Otis

Mark your calendars now for Reunion 2019! October 11–13, 2019

CLASS NOTES will appear in *Canopy* each spring.



# INSPIRING NEW CHAMPIONS FOR THE ENVIRONMENT

BY JOSH ANUSEWICZ



Johnae McArthur, one of five New Haven Promise interns at F&ES in 2018, spent last summer collecting and analyzing data from the Connecticut River.

LAURA LOGOZZO

**T**he walk was an arduous one.

Bushwhacking through thigh-high brush, ducking low-hanging tree limbs, searching for safe footing on loose rocks and muddy soil.

Johnae McArthur had spent plenty of time outdoors in her life, but wasn't expecting this kind of challenge in central Connecticut, less than an hour from her hometown of New Haven.

"Couple that with the heat and the bugs..." said McArthur, an undergraduate at the University of Connecticut. "But we got the work done."

McArthur spent the summer collecting and analyzing data with the Raymond Biogeochemistry Lab, headed by Peter Raymond, a professor of ecosystem ecology at Yale F&ES. The lab is conducting a large-scale analysis of the Connecticut River watershed to determine how dissolved organic matter (DOM) affects river processes, water quality, and carbon cycling.

For McArthur, a graduate of New Haven's Hill Regional Career High School, the experience was more than just a crash course in biogeochemistry or a chance to explore the woods of Connecticut. It also set her on a new career path.

She was one of five interns studying STEM-related fields hosted by F&ES this summer through the New Haven Promise program. The internship program, founded in 2011, provides full tuition scholarships to New Haven students at two- and four-year public colleges and universities in Connecticut. The scholarships are funded through a partnership between Yale University and The Community Foundation for Greater New Haven, with the mission to promote investment in education and economic development.

Other interns included: Bryanna Moore, a student at Yale; Kamil Wielechowksi and Joshua Lovett-Graff, students at the University of Connecticut; and Maryana Dumalska, a student at Boston College.

The program primarily serves students of color from lower income households — nearly 90 percent of applicants are either Black or Hispanic, and more than 40 percent are from households with an annual income of less than \$30,000. Since its founding, more than 1,500 scholarships have been awarded and more than 200 Promise Scholars have interned in more than 30 departments across Yale.

"These students bring experience from outside environmental studies, finding the interconnectedness between the academic areas they're passionate about and how they intersect with the environment," said Sara Smiley Smith '07 M.E.Sc./M.P.H., '16 Ph.D., Assistant Dean of Research and Sustainability at F&ES, who has worked with Promise interns for the past two summers.

"This program empowers them to champion the environment in their own ways, while leveraging the knowledge they gain here at F&ES to move on to successful careers."

McArthur worked for two months with Laura Logozzo, a Ph.D. student in Raymond's lab. She helped with all levels of fieldwork, which included maintaining measuring instruments in the river, downloading data collected by the instruments, and collecting water samples to return to the Yale laboratory. The samples were then methodically filtered and measured for dissolved organic matter,

which can alter the chemical composition and water quality of larger rivers and bodies of water downstream.

A chemistry major, McArthur had limited exposure to aquatic biogeochemistry heading into her internship, she said, but she came to value the practical skills she learned through research.

"I was introduced to other fields of study, and how to use instruments to collect and analyze samples," said McArthur. "I'm grateful to have learned so much and be introduced to new techniques."

Her introduction to biogeochemistry has also changed her focus of study, McArthur said. With the help of Raymond, she was referred to research professor Ashley Helton in UConn's Department of Natural Resources and the Environment. McArthur will volunteer as a researcher in Helton's lab this academic year and join a research project next summer.

"Biogeochemistry encompasses everything I want to do in my career," she said. "It can be applied to many fields — education, forensics, public health — so I have flexibility when it comes to research."

And the experience isn't just beneficial for the students — it's meaningful to the researchers.

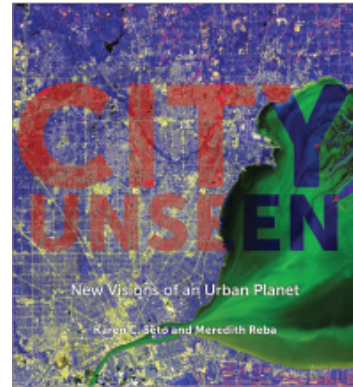
"Mentoring undergraduates is so rewarding — it's my favorite part of research," said Logozzo. "These students spend most of their time in classrooms or labs. When they're out in the field, the work they do is making a real difference."

"Working with students breaks up the monotony of day-to-day research. It re-inspires you and reminds you why you want to do this in the first place."





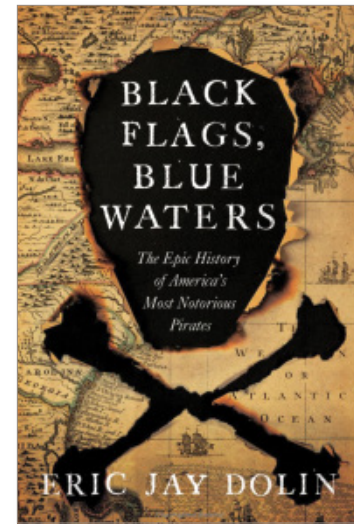
A satellite image of the port city of Manaus, Brazil, from *City Unseen: New Visions of an Urban Planet*.



**City Unseen:  
New Visions of an  
Urban Planet**

Karen C. Seto and Meredith Reba (Yale University Press)

Seeing cities around the globe in their larger environmental contexts, it becomes possible to understand how the world shapes urban landscapes and how urban landscapes shape the world. Using satellite data, Karen Seto, the Frederick C. Hixon Professor of Geography and Urbanization Science, and Meredith Reba '14 M.E.Sc., a research associate at F&ES, provide a revealing series of views that enhance readers' understanding of the shape, growth, and life of urban settlements of all sizes.



**Black Flags,  
Blue Waters:  
The Epic History  
of America's Most  
Notorious Pirates**

Eric Jay Dolin (Liveright)

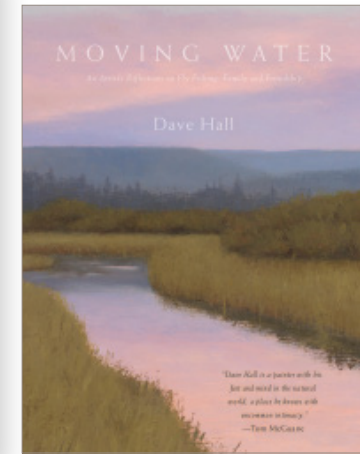
In his latest book, author Eric Jay Dolin '88 M.E.M. reanimates the "golden age" of piracy in the Americas. Set against the backdrop of the Age of Exploration, the book reveals the dramatic and surprising history of a period when lawless pirates plied the coastal waters of North America and beyond. Dolin illustrates how American colonists at first supported these outrageous pirates in an early display of solidarity against the Crown, and then violently opposed them.



**Global Resources  
and the Environment**

Chadwick Dearing Oliver and Fatma Arf Oliver (Cambridge University Press)

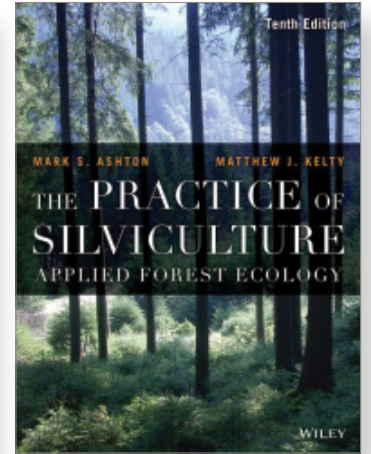
Over the past few decades, sustainability of natural resources and the social and environmental issues that surround them have become increasingly topical. This multidisciplinary book, co-authored by Chad Oliver '70 M.F.S., '75 Ph.D., the Pinchot Professor of Forestry and Environmental Studies, and his wife, Fatma Arf Oliver, tackles the complex relationships among society, natural resources and the environment. They examine each resource in the context of both environmental and socio-economic factors affecting their present and future distribution and demand.



**Moving Water:  
An Artist's Reflections  
on Fly Fishing,  
Friendship and Family**

Dave Hall (Blaine Creek Press)

This volume by Dave Hall '77 M.F.S., a writer and painter, includes stories that illuminate the mysteries and joys of fly fishing. According to Hall, the book was inspired in part by two grandfathers who loved the outdoors, by a rural New England childhood, and by "a lifetime of dawns and dusks." "Along the way," he writes, "a handful of friends have spent countless days in various countries longing for trout to rise and for bonefish to tail in the sweep of tropical tides."



**The Practice of  
Silviculture: Applied  
Forest Ecology**

Mark S. Ashton and Matthew J. Kelty (Wiley)

The tenth edition of this classic work co-authored by Mark Ashton '85 M.F., '90 Ph.D., the Morris K. Jesup Professor of Silviculture and Forest Ecology, includes the latest research on the many issues that are relevant to forests and forestry. Extensively revised and updated, this full-color edition covers such timely topics as biofuels and intensive timber production, management of public lands, ecosystem services, surface drinking water supplies, urban and community green space, forest carbon, fire and climate, and more.



# SELLING THE FARM

BY JOSH ANUSEWICZ

**A year ago, Joe Orefice '09 M.F. had an endowed position at Cornell and a beautiful farm nestled in the verdant Adirondack Mountains where he practiced silvopasture — the integration of trees, forage plants, and livestock.**

This summer, he gave it all up. Now, Orefice is the Director of Forest & Agricultural Operations at F&ES, putting him in charge of Yale's forest operations while also teaching courses in agroforestry and forest management.

*Canopy* caught up with Orefice to discuss his decision to return to F&ES and how he plans to integrate agriculture into the School's curriculum.

## **WHAT MADE YOU LEAVE CORNELL?**

It was ultimately the F&ES community that brought me back. It's such an engaging atmosphere that had a big impact on me as a student, opening me up to new ideas and providing opportunities to grow in my career. Also, the opportunity to work with faculty members who I hold in high regard, like Mark Ashton. They were important mentors to me, and I look forward to mentoring students and playing a role as they develop and go out into their careers.

## **THIS IS A NEW POSITION. HOW WILL IT WORK?**

I'll be working closely with Marlyse Duguid ['10 M.F. '16 Ph.D. the Thomas G. Siccama Lecturer], who serves as the research coordinator for the F&ES forests. While she oversees research and teaches, I will direct all of the different forest operations, like timber harvesting, the Quiet Corner Initiative, and the day-to-day management of the forests and facilities. I will also be teaching courses on temperate agroforestry and forest management, so teaching practical forestry courses to equip students with critical thinking skills.

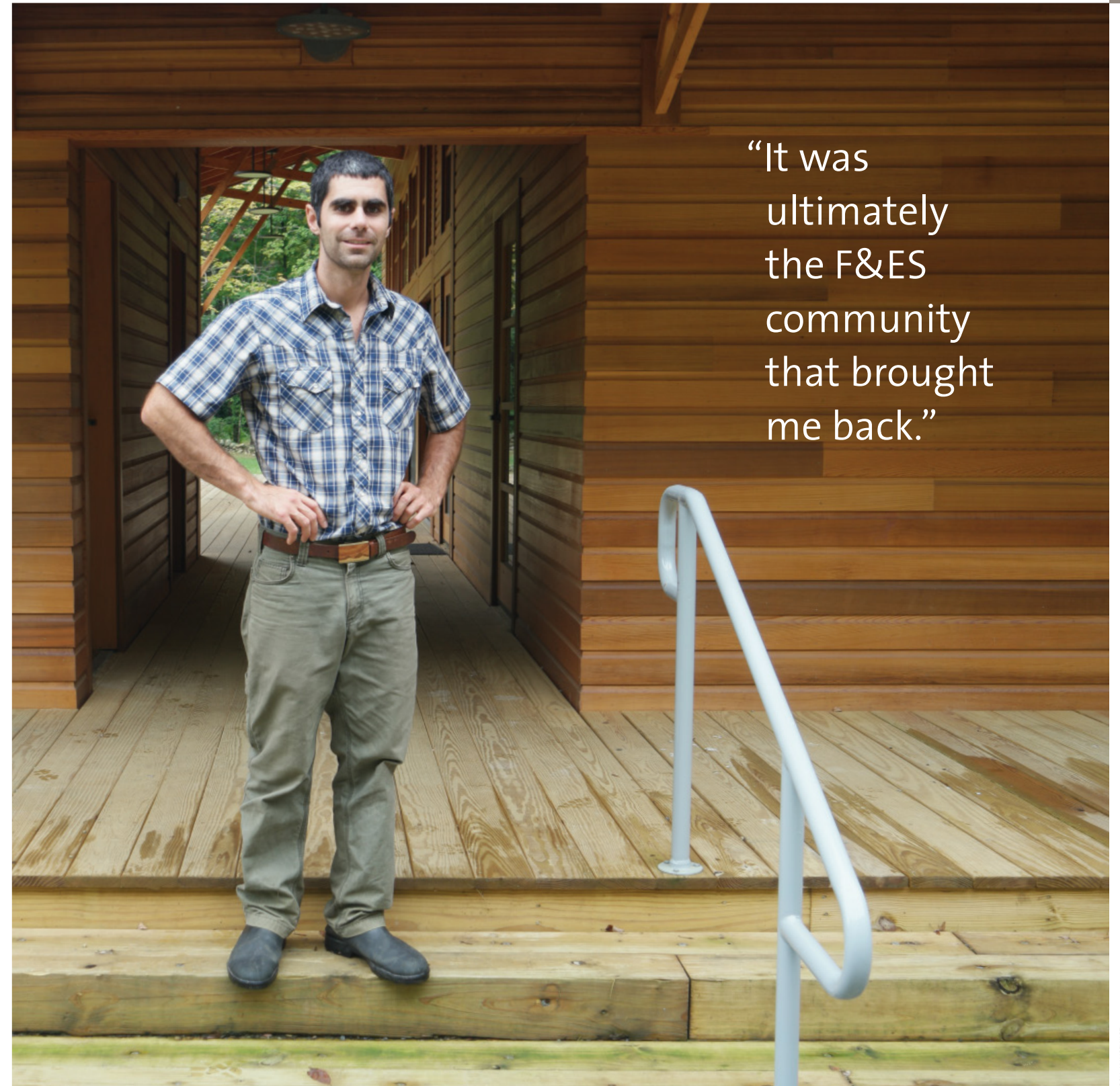
## **HOW WILL YOUR EXPERIENCE IN AGRICULTURE FIT INTO YOUR WORK?**

People have often asked, "What does Yale have for agriculture?" While new, agricultural opportunities at Yale are gaining momentum. Agroforestry is one way we can do it — maple is probably the best example in the Northeast — but for the School Forests to become a producer, we need to make sure that they're productive and financially viable. I think there is significant potential to offer agricultural education by utilizing the resources of the Yale Forests and connecting students with global partnerships in agriculture — especially agroforestry.

## **WHAT ARE YOUR THOUGHTS ON THE M.F. PROGRAM?**

One of my goals of the M.F. program is to build on a three-tiered system that F&ES has started to implement over the last decade.

I have always bought into the importance of providing students with a world-class curriculum that dovetails with practical experience. My teaching philosophy has been that the best education occurs when students are able to apply what they've learned. I am excited to work with my colleagues at F&ES as we take our forestry program to the next level.



“It was ultimately the F&ES community that brought me back.”



# CANOPY

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