Tracking Forest Change
New WHRC methodology reveals massive losses from degradation, disturbance

Science in New England
WHRC scientists study climate change and land use impacts close to home

Also in this issue
Women in science, work in Brazil, interview with John Holdren, outgoing and new Directors, annual report
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Cover: The map indicates loss (red) and gain (green) of aboveground forest carbon between the years 2003-2014. The colors represent a net value of forest carbon change per hexagon (10,000 km²). The Baccini et. al. (Science 2017) image pixel data was aggregated into a tesselated vector presentation for aesthetic purposes, allowing a smooth appearance over the entire tropic extent (full map on page 2), using Esri’s ArcGIS Pro software and methods developed by John Nelson, 2016 (https://adventuresinmapping.com). Map by Greg Fiske, Senior Geospatial Analyst.

Top: These vials containing ground plant matter were collected for analysis in WHRC’s lab by Laura Jardine during the summer Polaris Project expedition to the Yukon Delta of Alaska.
These days it is easy to feel discouraged. For one thing, the better we understand the science of climate change, the worse it looks. Projections of future sea level rise, for example, keep getting revised upwards, and recent hurricanes remind us that climate change is heightening risk from many forms of extreme weather. Furthermore, meeting the goal of limiting warming to 2°C (which might not be strict enough) is dauntingly difficult. Rapid cessation of fossil-fuel burning and deforestation won’t suffice; we need also to remove massive quantities of CO₂ from the atmosphere. All in all it appears increasingly difficult to avoid some serious and irreversible consequences. Evidence from climates of the distant past suggests, for example, that we may already be committed to many meters of sea level rise.

Under these circumstances we need strong action immediately, and this may seem unlikely when climate change deniers are in charge of major federal agencies, when the US is planning to withdraw from the Paris climate agreement, and when Trump is undoing climate and environmental protections as fast as he can write executive orders. As our President would say, “Very sad!”

Despite all of this, we have made remarkable progress recently, and there are some important reasons to feel optimistic. First, the Paris agreement is an enormous accomplishment—a roadmap for controlling climate change bought into by nearly every country (even North Korea). Also, costs of renewable energy have decreased stunningly and continue to drop, driving ever-wider adoption. For this and other reasons, greenhouse gas emissions from the US, the EU, and apparently now China are decreasing for the first time. The rapid progress in China (the world’s largest emitter) represents a dramatic repudiation of apocalyptic predictions made only a few years ago.

It is also encouraging to see state and regional climate policies growing in number and impact. This is encouraged (ironically) by increasing prominence of climate change impacts and by a backlash against Trump’s policies. Long-term prospects for action are increased by a growing priority placed upon climate change by the US public, and by an apparently greater value attached to environmental protection by the business community.

Where do we go from here?

The United Nations climate process will continue even without US leadership or participation. To help fill the void, our work at WHRC is increasingly focused on making the Paris agreement succeed, whether by helping countries to meet their commitments, or to monitor their progress as they head in that direction. Nothing we could do is more important, and we expect to expand this work even more in the near future.

Solving climate change will require farsighted land use policies that support preservation of ecosystem services (including safe global and regional climates), agricultural production, and human livelihoods. Nowhere is this tension more immediate than in Brazil, and our new partnership with Brown University is aimed at developing solutions there that can be replicated in other developing countries.

Woods Hole Research Center scientists have developed a cutting-edge methodology for measuring forest carbon loss. It turns out that much of this loss in tropical forests is from degradation – or the removal of individual trees from standing forests. Now that we can accurately and quickly measure forest degradation, we have a tremendous opportunity to stop it and keep carbon locked up in forests.

Arctic change will increasingly be recognized as a serious global threat, and once again our work is at the forefront both of understanding the emerging science and bringing it to the attention of policy makers. Closer to home, with or without federal leadership, states and municipalities will do more, and here again WHRC is stepping up to help with new work right here in Massachusetts.

As these examples suggest, WHRC’s work has never had more impact or been more urgently needed. Thanks to support from our many friends and dedicated work by our staff, WHRC’s finances are stronger than ever. Unfortunately, however, potential federal budget cuts create uncertain times ahead and necessitate continued vigilance and hard work. With your help, I know we’ll be able to do more than ever.

Thanks as always for your interest and support.

Philip B. Duffy
President and Executive Director
In November 2017, Alessandro Baccini stood in front of an audience in Bonn, Germany, and pointed to two different maps of tropical forests on the screen.

The first showed an area of complete deforestation. This represented the conventional and long-standing method of gauging carbon emissions from forest loss: use satellite imagery to measure the area deforested and then calculate the amount of forest carbon that was stored in that area before the forest was removed.

The second map showed a far more nuanced story, representing a new methodology that measures changes in forest biomass more directly, including gains from regrowth as well as fine-scale losses of trees within standing forests. These losses are referred to as forest degradation if caused by human activity and forest disturbance if caused by fires, droughts, pests or other natural forces. The darkest areas on the map represented the most intense depletion of forest biomass—and matched up perfectly with the deforestation image. But all around those completely deforested areas were lighter scattered patches of color.

“This is degradation,” Baccini said, showing the impact of humans on forests beyond the clear cutting.

Degradation—it turns out—might be the biggest challenge facing forests.

Baccini, an associate scientist at the Woods Hole Research Center, was addressing an audience at the annual United Nations climate change conference, also known as the Conference of Parties or COP. He was describing a state-of-the-art forest monitoring methodology, developed with several other WHRC scientists. The new method was designed to measure the changes in forest carbon that occur when trees are planted and grow (gains) or are removed (losses), measurements that were previously unavailable for much of the planet’s forests.

“It can be a challenge to map the forests that have been completely lost,” said WHRC scientist Wayne Walker. “However, it’s even more difficult to measure small and more subtle losses of forest. In many cases throughout the tropics you have selective logging, or smallholder farmers removing
individual trees for fuel wood. These losses can be relatively small in any one place, but added up across large areas they become considerable.”

The new methodology was published in the journal Science in October 2017 – and it revealed some disturbing news about the tropics. Widespread degradation and disturbance combined with deforestation has resulted in the region now losing more carbon than it captures - it should be a net sink for carbon, but instead it’s a source. The researchers found that this biomass loss from tropical forests has caused a net loss of carbon to the atmosphere – about 425 teragrams of carbon annually, which is more than the emissions from all cars and trucks in the United States.

“These findings provide the world with a wakeup call on forests,” said WHRC scientist Alessandro Baccini, the report’s lead author. “If we’re to keep global temperatures from rising to dangerous levels, we need to drastically reduce emissions and greatly increase forests’ ability to absorb and store carbon. Forests are the only carbon capture and storage ‘technology’ we have in our grasp that is safe, proven, inexpensive, immediately available at scale, and capable of providing beneficial ripple effects, from regulating rainfall patterns to providing livelihoods to indigenous communities.”

The study used 12 years (2003-2014) of satellite imagery together with laser remote sensing data and field measurements to quantify changes in aboveground forest carbon across tropical America, Africa and Asia—the most threatened forests in the world—and those with the greatest ability to store significant amounts of carbon and preserve biodiversity and essential ecosystem services for millions worldwide. The study found that forest degradation is responsible for nearly 70 percent of all carbon lost from tropical forests.

Losses and gains of carbon were not evenly distributed across the tropical belt. The majority of the loss (nearly 60 percent) occurred in Latin America, home to the Amazon—the world’s largest remaining intact rainforest. Nearly 24 percent of the loss was attributable to Africa while 16 percent came from Asian forests.

The research showed that with the exception of Asia, degradation and disturbance were responsible for the majority of continental losses. In the Americas, 70 percent of losses were due to degradation and disturbance; in Africa, it was 81 percent. Almost half—46 percent—of losses in Asia were linked to degradation and disturbance.

To the surprise of some in the audience, Baccini wrapped up his remarks by emphasizing that this new information represents a critical tool in fighting climate change. “With this study, we have lifted the fog that has been hampering local to global efforts to take aggressive action on forests,” Baccini said. “Now, countries can not only identify where degradation is taking place, but also, given the potential to now measure gains from growth, they can demonstrate their contributions to returning tropical forests to their more beneficial role as a carbon sink. We envision this tool improving the way countries across the tropics tackle the challenges of deforestation and degradation.”

Visit thecarbonsource.org to view and download data.

This research was supported by NASA Studies with ICESat and CryoSat-2 (NNX13AP64G) and Carbon Monitoring System (NNX14AO81G) grants.
Why aren’t there more senior female scientists?

As a Ph.D. student studying fish in Louisiana, Dr. Linda Deegan needed to go out on the water for her research. Senior scientists in her department, however, said that she would need a male researcher with her if she were going to take a boat out.

“We were told that if the boat broke down, he could fix it,” she said. “Or if some wild Cajun fishermen tried to accost us, he would protect us.”

Now a senior scientist at WHRC, Deegan recalled that the male scientist she was supposed to take on her boat was significantly less capable than any of the female researchers.

“But that was in the 1980s,” she said. “That was the attitude.”

Deegan also remembered attending a social event with colleagues and being told that “you have to grow a mustache to be successful in this field.” At conferences, she said, it was not unusual for male scientists’ presentations to include a slide of a woman in a bikini holding a fish.

She said that over time, attitudes toward early-career female scientists have become less overtly hostile, but “there’s still pressure that is still pushing women out of the field.”

Attrition

That pressure is having a measurable effect on women in science careers.

Across the scientific spectrum, the gender balance for junior researchers is roughly equal. According to the National Academies, there were more female (247,047) than male (217,734) graduate students in scientific programs in 2011.

But as scientists move into more senior roles, that balance shifts dramatically.

“You see steady drop-offs at every career stage,” said Dr. Heather Goldstone, who hosts the science radio program Living Lab on National Public Radio stations WCAI and WGBH.

WHRC Arctic scientist Dr. Sue Natali said that “we’re fine to the Ph.D. level and that’s when we start to lose them.”

The lower proportion of senior female scientists in society is mirrored at the Woods Hole Research Center. Among the research staff (including research assistants, research associates, post-docs, etc., but excluding primary investigators) women slightly outnumber men, 14 to 12. But for primary investigators, men outnumber women 15 to 3.

“The under-representation of women in senior scientific roles means that we are not getting the benefit of a lot of talent, and hence we are underperforming as an institution,” said WHRC President Philip Duffy.

On the national level, researchers and experts have pointed to a variety of causes for this imbalance – ranging from hostility and harassment to inflexibility for working mothers.

“It’s a systemic problem,” Deegan said. “The reasons for it have changed slightly over time but the result is the same. Social pressures are still pushing women out of the field.”

Dr. Kathryn Clancy, an associate professor of anthropology at the University of Illinois, said that hostility often drives women out of the sciences. Clancy has written and spoken extensively about the challenges facing women in sciences and higher education and she said the pressure can come from overt hostility or more indirect experiences, such as “someone walking by you and acting like you aren’t even there.”

She said that these perspectives become ingrained, and the legacy of hostile interactions could also drive younger researchers out of the sciences.

“Folks will look at what a lot people before them have gone through, and even if they haven’t experienced it yet they’ll take themselves out of the profession,” Clancy said.

Scientists also point to societal expectations and the challenge of work-life balance.

“Women start a family and it’s pretty much assumed that they are going to step back,” Deegan said.

Goldstone said that she chose to move from research into journalism in part because of her young children and the demands of her post-doctoral research.

“There are tons of studies on why it is that we see this attrition of women, trying to look for something other than motherhood,” Goldstone said. “But ultimately, motherhood is a huge part of it.”
Solutions
Natali said that there are basic policy changes that all institutions should embrace – such as improving paid family leave. But each institution also needs to develop institution-specific guidelines.

“There are definitely policies that science institutions can put into place that will help. But a lot of it is a much broader societal change, about giving partners equal responsibility,” Goldstone said.

Clancy said that to deal with hostility issues, organizations should adopt diversity training, implicit bias training, and “affirmative training over sexual harassment training. Getting people into a room and asking what are our shared values? What would it look like to be collegial?”

Ludwig said also that having more female mentors would encourage female scientists to take risks that they wouldn’t otherwise take.

“I don’t think women apply for projects that they are qualified for,” Ludwig said. “You just grow up with people telling you that you can or can’t do things. We don’t have enough people telling us that we can.”

Looking to create a network for mentorship and support, this March Natali launched the Woods Hole chapter of a national group called 500 Women Scientists. That chapter rapidly grew to become one of the largest in the nation.

Creating Change

“Overall, I’m pretty hopeful,” Clancy said. “I’m hopeful because I’ve encountered a lot of individuals who are committed to creating change. Individuals who are committed to changing their field sites, their labs, their boats.”

Deegan agreed that times are changing.

“A lot of it was generational, and those people are moving on,” she said. “Now it’s shocking if I go to [a conference] and there’s a picture of a woman in a bikini holding a fish.”

Deegan cautioned, however, that some biases still remain firmly entrenched.

“For example, women who exhibit certain traits are considered bossy and pushy, but men who have the same traits are leaders,” she said.

Deegan said that scientists have to be “really conscious of choices we make” in nominating colleagues for awards, suggesting speakers for panels, and choosing authors for papers.

“We’re not going to change everything tomorrow,” Natali said. “But we need to identify our biases and take steps to create change.”

WHRC’s leadership is committed to doing just that, a pledge which is expressed explicitly in the organization’s new strategic plan.

“For the Center to be a part of the solution, we must start by taking an honest look at our own environment,” Duffy said. “That is why we are evaluating our own policies and practices, with the goal of fostering a community of inclusion, and creating more opportunities for women to advance their scientific careers.”

Several scientists interviewed for this article said that having more female mentors in the sciences would also make a difference.

“It’s a self-perpetuating cycle,” Natali said. “If you don’t have the female mentors, you can’t see yourself in that role.”

Natali works with several young scientists, including research assistant Sarah Ludwig. The two initially met when Ludwig was a student in WHRC’s Polaris Project studying soil enzymes in Siberia. Ludwig said early in her academic career, she only had male mentors but that working with Natali gave her confidence, including in working with scientists in Siberia who were casual about making misogynistic comments.

“It was great hearing Sue give the same [attitude] back to them,” Ludwig said. “Sue has always looked out for me. She was a real mentor, knowing when to listen, figuring out the things that I like and helping me work on the stuff that I get really excited about.”

Ludwig said also that having more female mentors would encourage female scientists to take risks that they wouldn’t otherwise take.

“I don’t think women apply for projects that they are qualified for,” Ludwig said. “You just grow up with people telling you that you can or can’t do things. We don’t have enough people telling us that we can.”

Looking to create a network for mentorship and support, this March Natali launched the Woods Hole chapter of a national group called 500 Women Scientists. That chapter rapidly grew to become one of the largest in the nation.
In the 1990s, when the Amazon rainforest was being burned to create pastures for cattle, small streams were dammed to form reservoirs—or watering holes—for cattle. In some regions, these cattle ranches have largely been replaced by soybeans and other commodity crops, but thousands of "cattle ponds" remain. These reservoirs fragment stream ecosystems, increase water temperatures, and are thought to contain significant amounts of methane and carbon dioxide. Given their sheer number, reservoirs could well be a large source of greenhouse gas emissions to the atmosphere—and one that has not been accounted for in the carbon budget.

Dr. Marcia Macedo studies land use change from agricultural expansion in the Brazilian Amazon. Her prior research using satellites to map reservoirs led her to consider greenhouse gas emissions from the cattle ponds that dot the Amazon-Cerrado agricultural frontier. Last year, she was awarded a J. William Fulbright Scholarship to spend six months in Brazil building new research collaborations and kicking off field research on the reservoirs. Macedo is the fourth scientist at WHRC to receive a Fulbright.

While in Brazil, Macedo did her fieldwork at Tanguro Ranch in the state of Mato Grosso, where WHRC has conducted research since 2003. She collaborates with partners at the University of Brasília (UnB), the Federal University of Goiás (UFG), and the Amazon Environmental Research Institute (IPAM), WHRC’s long-time Brazilian partner.

Tanguro Ranch, which is about the size of Cape Cod, Massachusetts, contains at least 50 of these reservoirs. Macedo and her team are using floating chambers on the surface of the ponds to collect gas, submerged funnels to collect bubbles, and water samples to measure the amounts of methane and carbon dioxide in the water column. Her study will result in the first comprehensive estimate of greenhouse gas fluxes from these small reservoirs.

The Fulbright project focused on the Xingu watershed as a first step. A grant from NASA is supporting Macedo’s ongoing work to combine these field observations, drone surveys, and satellite observations. Ultimately, the project will estimate the total annual emissions from reservoirs over the entire Amazon-Cerrado agricultural frontier.

“The most exciting aspect of this project has been bringing together a diverse team of collaborators and a range of tools that allow us to tackle this problem from a variety of perspectives and spatial scales,” notes Macedo. Among others, she has worked with WHRC’s Kylen Solvik, who has developed computer algorithms able to quickly map reservoirs over large areas. She is now working with two Brazilian students from UFG, who are conducting drone surveys to estimate reservoir size and vegetation cover.

“The Fulbright scholarship provided an exciting opportunity to sink my teeth into a research question we’ve been thinking about for years,” Macedo said. “My six-month stay allowed me to collect new field data, work with world-class ecologists at UnB, and strengthen our existing collaborations with IPAM at the interface of science and policy.” During her Fulbright award, Macedo was based at the University of Brasília alongside her long-time colleague, Dr. Mercedes Bustamante.
WHRC scientists conduct research on climate change and natural systems around the world. But some of our work also keeps us close to home – right here in New England. Our local work includes salt marshes and forests, suburban ecosystems and regional watersheds. Fundamentally, though, all of our projects focus on the effects that land use and climate change have on natural systems – and vice versa.

In the following pages, we have highlighted a few of our local projects.
Dr. Chris Neill spends a lot of time thinking about watersheds and coastal ecosystems. Neill is an ecologist who studies watershed biogeochemistry, plant ecology, and ecosystem restoration from Massachusetts to the Amazon. At any one time, he is managing multiple research projects that explore how land can be managed better to minimize impact on ecosystems. Sitting in his office at the Woods Hole Research Center, Neill described the potential impact from cranberry bogs.

“About a quarter of the U.S. cranberry crop comes from Massachusetts, and almost all of this production occurs in coastal watersheds in southeastern Massachusetts. Cranberry bogs use fertilizer, about 35 kilograms per hectare per year of nitrogen,” Neill said. “Cranberry farming relies on flooding, particularly for harvesting and protecting from winter damage – and the farmers use ponds and rivers for discharge.

If it is not managed carefully, he explained, these discharges of nitrogen can flow downstream where they can affect freshwater ponds, coastal salt marshes and estuaries.

Excess nitrogen causes the root systems of marsh grasses to grow slower, organic matter to decompose faster, and the structure of the salt marsh along creeks to collapse. Excess nitrogen in water can cause oxygen depletion, diminishing fish and shellfish populations. That nitrogen can come from runoff fertilizer used on lawns, from septic tanks, and from agriculture.

Neill and collaborators at the Buzzards Bay Coalition, the Marine Biological Laboratory and the UMass Cranberry Station studied cranberry farming as a source of nitrogen. They found willing partners in the cranberry farming community.

“Nutrient inputs are costly and growers do not want to waste financial resources on applications beyond what is needed,” said Dr. Carolyn DeMoranville, the former director of the UMass Cranberry Station. DeMoranville worked with Neill on the project. “Likewise, most Massachusetts cranberry growers live near their bogs; they have the same interests in clean water as their neighbors.”

From 2015 until the fall of 2016, the team chose three bogs in southeastern Massachusetts and set up programmable auto-samplers to collect daily water samples, as well as extra samples during floods, and heavy rains in the summer. “The events we were targeting for sampling were the harvest and winter floods, rain events, and background nutrient concentrations,” said WHRC scientist Lindsay Scott. “We needed detailed measurements of nutrients entering and leaving the system via surface waters.”

The study produced the most detailed measurements yet made of nutrient discharge from cranberry bogs and actually showed that the impact was slightly less than was previously understood, according to Neill. He said that the results also showed the most significant nitrogen runoff was not during the flooding periods, but during the constant flow of water through the bog.

“That’s something we can address,” Neill said. “If it is coming out through the slower constant flow, there is something we might be able to manage.”

“Now that we know nitrogen flows from this small number of bogs, the next challenge will be to scale up to predict effects on a whole watershed and to try to predict nitrogen exports from bogs based on their characteristics such as soils and position in the landscape, according to Neill.

“This study continues to build the story of how different bog configurations and water management activities contribute to off-site nutrient movement,” DeMoranville said. “These studies help to determine how growers might modify their management activities to limit nutrient movement.”

The work was funded by the Massachusetts Executive Office of Environmental Affairs through an award from the Southern New England Coastal Watershed Restoration Program Nutrient Management Grants to the Buzzards Bay Coalition. It was also supported, in part, by the U.S. EPA.
For many years, WHRC’s Deputy Director and Senior Scientist Max Holmes has been interested in rivers and watersheds and the ways in which climate change affects their health. He has spearheaded long-running projects to study rivers in the Arctic—the Arctic Great Rivers Observatory (Arctic GRO) project—as well as the world’s largest rivers through the Global Rivers Observatory (GRO).

Last year, Dr. Holmes initiated a study of rivers close to home with the Cape Cod Rivers Observatory project (caperivers.org). Applying methods that he has used on large rivers around the world, the Cape Cod Rivers Observatory is investigating the chemistry of six rivers in order to track their health and that of their watersheds.

Holmes works closely with Rob Stenson, a member of the WHRC President’s Council and a volunteer on the project. Stenson goes out once each week to collect samples from the six rivers and brings them to WHRC’s laboratory for analysis.

The rivers in the study are the Santuit River, Masphee River, Quashnet River, Coonamessett River, Herring Brook, and Red Brook. Analyses of water samples, showing chemical composition and temperature, are updated on the project website.

“I’m a volunteer citizen scientist, and it is a real joy to get out there and contribute to solving the pressing issues of climate change,” Stenson said. “The weather is my only real drawback, ice and snow in winter. I had to snowshoe into Red Brook once this past winter. But Red Brook is my favorite river to sample as I often see osprey, deer, and wood ducks.”

The Cape Cod Rivers Observatory team also includes Senior Geospatial Analyst Greg Fiske and Research Assistant Anya Suslova. “We’ve been looking at the world’s big rivers,” said Holmes, “and we’ve been ignoring rivers in our own back yard.” He hopes that as the project continues it will pique the interest not only of scientists, but also of students and the general public.

Stenson also said that he hopes the research can help raise awareness of environmental health issues.

“We have only been at this for a year but we have amassed quite a large data base to work from,” Stenson said. “I believe we will have a much more complete understanding of nitrogen loading and the profound effect that that has on our rivers and their watersheds.”

The CCRO is funded in part by MF Bartol Charitable Giving Fund and the Harbourton Foundation.
Howland Forest

Scientific impact of WHRC’s longest running research site

Man is setting in motion a series of events that seem certain to cause a significant warming of world climates over the next decades unless mitigating steps are taken immediately. The cause is the accumulation of CO$_2$ and other heat-absorbing gases in the atmosphere. The result is expected to be a differential warming of the atmosphere near the earth’s surface, a warming that will probably be conspicuous within the next twenty years. If the trend is allowed to continue, climatic zones will shift, and agriculture will be displaced. Such a series of changes would have far reaching implications for human welfare...

- George M. Woodwell’s Congressional testimony in 1979, six years before he founded Woods Hole Research Center

In the late 1980s, Dr. Woodwell and senior scientist Richard A. Houghton recognized the need to measure the exchange of CO$_2$ between land and the atmosphere. The two had been successful in "using measurements of carbon dioxide in air to make what were probably the first appraisals of respiration of a forest," recalled Dr. Woodwell. “So it was understandable that I was interested in seeing the further development of those measurements, especially simple monitoring of air over time.”

Coincidentally, researchers at the University of Maine in Orono were working on similar issues at Howland Forest, a small section of a large tract owned by the International Paper Company. The company had established an “experimental woods” and was running a project through the university to determine the length of time it would take to regrow a harvested forest. Woodwell found support for WHRC to join with UMaine in measuring the respiration of the forest and in the fall of 1989 a
young WHRC research assistant, Paul Lefebvre, began work at Howland.

A gifted technician, Lefebvre perfected and programmed a data logger to record CO₂ measurements. Every few months he made the six-hour drive from Woods Hole to the forest, where in winter he pulled a sled carrying a 30-pound computer for an hour to reach the site.

At the core of the one-square-mile research site is a 35-meter tower rising above the forest canopy. Air intakes to measure ozone and carbon dioxide are situated at varying levels on the tower. In the beginning, Lefebvre’s method of measuring fluxes was somewhat rudimentary, but it was the precursor to eddy covariance, the technique now used widely around the world. It was also the era of the floppy disc, and UMaine researchers would regularly download the CO₂ data and mail the precious disc back to Lefebvre at WHRC.

Management of the Howland Forest project was passed on to biogeochemist Kathleen Savage, who joined WHRC in the late 1990s and since then has worked on various Howland studies. Research assistant Holly Hughes also worked for two decades with Ms. Savage to monitor the forest. The two researchers have spent countless days and hours measuring aspects of the forest and inventing new techniques for monitoring carbon stocks – amidst the moose, black bears, bobcats, and bald eagles that inhabit the forest.

In the early 2000s, an investor interested in logging bought the forest. Scientists at UMaine and WHRC became concerned about the fate of the research site and contacted the Northeast Wilderness Trust to seek a solution. In 2007, the Trust raised $1 million to purchase the 550 acres of land, which ensured that Howland research would continue and the forest would be permanently protected.

The first tower to measure carbon emissions at Howland Forest turned out to be one of the longest running research towers in North America. Three more research towers were added, and in 1996 the forest became the first base site for the Department of Energy’s AmeriFlux Network. These data now reside at the University of California Berkeley’s AmeriFlux archive.

Howland’s temperate boreal transition forest has been the focus of studies on acid rain, forest ecology, ecosystem modeling, nutrient cycling, and carbon sequestration—hence, climate change research. Scientists from WHRC as well as many NGOs and federal agencies have run a multitude of projects at the site, whose record of carbon flux measurement is one of the world’s longest.

This research is currently supported by USDA - National Institute of Food and Agriculture.
WHRC scientists have found that added nutrients (like nitrogen) can destroy a salt marsh by increasing the size of grasses and decreasing the size of their roots. In this photo taken last year at Plum Island, MA, David Behringer used a tow-across Acoustic Doppler Current Profiler to measure water velocities in a creek channel. Scientists used that information to calculate tidal discharge and understand nutrient retention in the marsh.

WHRC scientist Dr. Linda Deegan spoke to a group of young students about the restoration of the Coonamessett River in Massachusetts. Deegan is part of a team that is restoring the river, including removing impediments to the migration of herring and other fish species.

Woods Hole Partnership Education Program (PEP) students visited WHRC’s campus to measure trees and analyze soil. Two students spent much of the summer studying above ground biomass and soil carbon at WHRC.

WHRC scientist Hillary Sullivan traveled to Cuttyhunk Island off the coast of Cape Cod with a group of middle school students from Mattapoisett, MA. The students learned about salt marsh zonation, and how to take cores and look at below ground biomass.

WHRC scientist Robert Coady samples an exclosure plot for plant diversity on a rainy day on Naushon Island off the coast of Cape Cod. WHRC is studying how ecosystems recover after agriculture is abandoned.
Forests for fuel

This October, experts came from around the world to the Woods Hole Research Center to examine in detail the proposition that forests provide a renewable source of energy that can be exploited in massive quantities to replace coal and oil in production of electric power.

The core of the discussion was the need to replace fossil fuels in the generation of electricity with a “renewable” source of energy. Forests are, nominally at least, “renewable”, at least on the scale of decades to a century. It is also true that the market for forest timber is limited and becoming more specialized as the markets for paper and lumber are reduced. The “renewability”, however, is decadal while the build-up of carbon in the atmosphere is substantially immediate. There is, of course, a longer-term further release as the organic matter in the harvested forest soils decays.

A visit recently to Beaufort, North Carolina, offered a glimpse into this now well established industry. My flight into Jacksonville in the North Carolina coastal plain, on a perfectly clear October day, gave me a survey of a landscape marked by farms and row-crop forests interspersed with mile-square clearcuts. A film shown recently at WHRC extended the clearcuts into gum/cypress forests in the wider coastal plain. Those forests of magnificent trees are hundreds of years old and replaceable only over a century or more, if then.

Pushing on by car I encountered Morehead City, devoted, apparently, exclusively to the management of wood chips, stored in enormous domes and pumped in bulk onto ships destined for European ports to replace coal in the generation of electricity.

The conference at WHRC was to examine in detail such operations, which appear on first glance to be wasteful, if not counter productive in advancing interests in the urgent mission of reducing carbon emissions in production of electrical power. Participants came well armed with detail including a highly refined mathematical model produced at MIT that made quantitative appraisals of carbon flow through harvest and successional restoration of forests. It was impressive and it confirmed in satisfactory and rewarding detail the timing and flow of carbon and energy through forests under various harvesting regimes.

The role of forests in the global carbon cycle is now clearly defined, essential, and it does not extend to feeding an industrial energy source, however tortured by economic gradients and incentives. It is a classic example of how biophysical realities set limits on economic and political adventures. The biophysical reality is the size of the carbon mass in forests and their soils, several times the mass of carbon in the atmosphere, and the magnitude of the normal flows of carbon through photosynthesis and respiration, each about ten times the human-caused release through burning fossil fuels. The composition of the atmosphere has been set in the past by equilibria established among those stocks and flows as they are affected by exchanges with the oceans, another gigantic but somewhat less mobile pool.

Disrupting those large stocks and flows has the potential for affecting the composition of the atmosphere profoundly in the short term. Now that we have raised the heat-trapping gas content of the atmosphere to the point of inducing significant warming of the entire earth, management of the stocks and flows has become essential. The very first step in management is a cessation of deforestation globally coupled with efforts to re-establish forests on normally naturally forested lands now deforested and abandoned.

There is no circumstance that makes forested land, however managed, a source of renewable energy and an appropriate substitute for coal in power plants anywhere in the world.

There are, of course, reasoned and correct arguments that domestic heating needs can be met renewably with locally produced wood. The intensity of such harvests is often at the level of “land management for timber and wood” of the order of “a cord, more or less, per acre per year”, an age-old harvest. The clearcut for fuel is a far cry from such management.

The bioenergy workshop was presented and funded by Pivot Point, New England Forestry Foundation, and Clean Air Task Force.
WHRC works with farmers to stop Amazon deforestation

In the Brazilian state of Mato Grosso, farmers are required to keep 80 percent of their land forested.

While that policy appears to be a conservation success, the reality on the ground is that most landholders already have more than 80 percent forest cover on their land. To maximize revenue, many farmers are looking to clear land to get down to the 80 percent floor.

WHRC scientists want to convince them otherwise.

“The difference between the forest they actually have, and the 80 percent requirement is the surplus,” said WHRC’s Dr. Glenn Bush, an environmental economist. “We’re trying to protect that surplus.”

Deforestation and forest degradation (removal of small numbers of trees instead of clear cutting) contribute about 10 percent of global carbon emissions. That’s comparable to annual emissions from all cars and trucks on the road today. And while cutting forests releases carbon dioxide into the atmosphere, it also removes a valuable carbon sink that would be absorbing excess greenhouse gases.

The largest tropical forests in the world are in the Amazon, and much of WHRC’s work in Brazil is focused on keeping forests intact. Bush is working with WHRC’s Amazon team to meet with farmers and devise economic strategies that would avoid deforestation.

“We’re holding focus groups and implementing a survey to understand farmer motivations for clearing new areas of forest on their private landholding,” Dr. Bush said. “Obviously it hasn’t been cleared already, so there are opportunities but there are also constraints. If we can understand the constraints and we can understand the triggers for deforestation, we can help them avoid it.”

The team wants to launch a pilot project with the Mato Grosso state government, with direct payments or another market-based plan to provide incentives for farmers to keep their forests intact. The ultimate goal is to work with the state to launch a large-scale project.

The Environmental Defense Fund—a long time WHRC partner in the region—is developing a strategy to secure international financing for the effort.

Right now, Dr. Bush is still meeting with farmers and developing the survey.

“We’re meeting with different types of farmers, doing different types of farming,” he said. “Large and small. Arable agriculture and livestock.”

Smaller farmers, it turns out, tend to keep animals and grow crops. Medium and larger farmers tend to specialize. The larger survey will be completed by the end of the year.

Dr. Bush said that in his initial conversations with farmers, they were hesitant to acknowledge that deforestation could accelerate climate change but they were acutely aware of the impact that forest cover change has had on rainfall. They were all open to the idea of payments to stop deforestation.

“They were very receptive to this idea,” he said. “And why not? If someone is going to give you money to maintain the status quo you don’t have to put the work into clearing. You don’t have to go through the effort of getting loans. You don’t have to take the risk, but you’re getting income from that land.”

The challenge in designing the plan from an economic perspective, Dr. Bush said, is conserving the maximum amount of forest as efficiently as possible.

This research is supported by the Norwegian International Climate and Forest Initiative and the Climate and Land Use Alliance.
The Initiative will combine the collective experience of both organizations working with private and public sector decision-makers in Brazil to create positive change in one of the world’s largest agricultural frontier. The group toured research stations at Tanguro Ranch, WHRC’s longstanding Amazon field station, and also heard from a wide array of partners who are working on the same conservation challenges.

Two months later, WHRC President Dr. Phil Duffy and Dr. Amanda Lynch, Director of the Institute at Brown for Environment and Society finalized a memorandum of understanding that will create a new partnership focused on the grand challenge of preserving the natural ecosystems upon which we all depend, while nourishing more than 10 billion people, and stabilizing global climate at levels that avoid catastrophic consequences. The Brown-WHRC Global Solutions Initiative aims to help resolve these intertwined issues through rigorous application of environmental, political, and social science, policy interventions, and capacity building.

The Initiative will combine the collective experience of both organizations working with private and public sector decision-makers in Brazil to create positive change in one of the fastest-evolving regions on Earth; where farms, diverse rainforests and savannas, and precious water resources are being threatened by local and global climate change. Together, we will spend the next ten years turning the most up-to-date physical and social science understanding of the synergies between food, people, and climate into effective policies that promote the wellbeing of people and protect the natural systems upon which they depend.

Why Brazil?

Deforestation – and the conflict with expanding agriculture – is most apparent in developing tropical nations. Brazil’s recent emergence as a global agricultural powerhouse sets it apart from all other countries. To date, the amount of tropical forest that has been cleared in the Amazon and Cerrado is larger than France, Germany, Italy, Great Britain, and Portugal combined.

In Brazil, growth in agricultural production has gone hand-in-hand with important improvements like better access to schools and healthcare, but continuing agricultural development threatens the natural systems that underpin this recent prosperity, according to WHRC senior scientist Dr. Michael Coe.

“Deforestation for agriculture in Brazil is destroying its bio-diverse savanna and the largest tropical rainforest in the world while degrading the climate,” Coe said. “Brazil's response—promising to double agricultural production while ending deforestation—defines a goal that if achieved would increase economic development, provide much of the needed global growth in agriculture, halve Brazil's carbon emissions, and protect biodiversity and climate.”

A Global Solutions Initiative

While Brazil has already achieved some conservation successes, delivering on this new bold promise will require partnership and a large-scale commitment to deliver effective and comprehensive knowledge and scientific solutions. Together, Brown and WHRC are well-positioned to develop the training, conservation, and agricultural pathways that will help Brazil succeed in achieving its ambitious goals. Specifically, the Initiative will be built around three strategies:

1) Produce innovative and rigorous science to understand the interdependent social and natural systems of Brazil;

2) Collaborate with Brazilian partners such as NGOs, policymakers, and agriculture industry leaders to promote policies supporting forest conservation and human wellbeing;

3) Through educational programs and trainings, develop the next generation of researchers, policymakers, and communicators who will carry this work into the future.

“It is essential that growth in countries like Brazil occur without compromising the ability of natural systems to sustain it,” Dr. Coe said. “Brazil presents an immediate opportunity to demonstrate how applied science and public policy outreach can achieve critically important sustainable development goals. The complementary expertise of Brown and WHRC offers an ideal partnership to make those goals a reality.”
Dr. John Holdren was the president of the Woods Hole Research Center from 2005 to 2009 – when he left to become President Barack Obama’s science advisor and the head of the White House Office of Science and Technology Policy. Dr. Holdren served in those roles for all eight years of President Obama’s time in office, and he became the nation’s leading voice for integrating science into policy.

In January 2017, Dr. Holdren returned to WHRC in a pro-bono role – as a senior advisor to President Phil Duffy. Dr. Holdren also returned to his professorships at both the Kennedy School of Government and the Department of Earth and Planetary Sciences at Harvard University. In 2017, WHRC honored Dr. Holdren’s career and lifetime of achievement by awarding him the Huntington Prize.

WHRC: How would you describe your time in the Obama Administration?

It was an amazing privilege and opportunity to serve as the top science and technology advisor to President Obama in the White House, not least because he understood how and why science and technology mattered to everything else on his agenda. He just got it. He was determined to bring science and technology to bear on all the national and global challenges on his plate. That very positive and forward leaning stance on science and technology made my job particularly rewarding.

You’ve mentioned before that President Obama did his science homework.

He not only understood in his core why science and technology mattered, he proved to be exceptionally well informed, even though he had a relative lack of formal scientific preparation in his background. I expected that a lot of the time I spent with him would be in a tutorial mode - explaining possibilities, how science and technology work, and what the big issues were. Instead, he knew the basics and nearly all of the time we talked about how we were going to move the needle. We talked about how we were going to bring science to bear in addressing big challenges.

There has never been a time that being outspoken is more important.

We talked about raising the nation’s game in science and technology education and about reviving US bilateral and multilateral scientific cooperation with other countries. We talked about how we were going to use science and technology, and what is the federal government’s role?

President Obama is just extremely smart and it’s always a pleasure to work with someone who is so quick, so discerning. You never had to tell him anything twice. His other senior staff members and I would give him long, dense briefing memos on complicated topics; he’d read them overnight, and in the next day’s meeting on the topic he would summarize the issue, without notes, in a way that was better than the memo.

The White House seemed to celebrate science a great deal while you were there.

He talked more about science, I think, than any other president in history. He held more events in the White House to celebrate science. He probably had more kids in the White House for science and technology events than he had sports teams. And you could see in those photo ops was how genuinely excited he was to be with young people talking about science and technology.

What do you think of the role of science in the Trump Administration?

The outlook, I have to say with regret, is not good. We’ve seen a lot of really terrible signs about the greatly diminished role that science, technology, and evidence are going to play in the new administration.

I’ll start with the president himself, who apparently can’t distinguish between fact and what he wishes were true. And he trashes anyone who points this out. He and his enablers have been engaging in shameless serial lying and evasion. And nobody there seems to be bothered if the president says one thing in a tweet
one day and then his spokesperson says the opposite thing the next day.

This is absolutely absurd, and I think that in its extent and degree it is unprecedented in the American presidency. This total disregard for fact and evidence bodes very ill for the use of science and technology in government to address national and global challenges, as well as for the role of government in supporting science and technology through investments in basic and early-stage applied research, in science and engineering education, and in other important ways such as high-skills immigration policy and public access to government data.

Trump appointed a climate-change contrarian, Scott Pruitt, to run the EPA. A number of Pruitt’s staff are from the office of Senator James Inhofe, the most notorious climate change contrarian in Congress, and others are from the polluting industries that EPA is supposed to regulate. This is already mind-boggling. And then President Trump listens to Scott Pruitt and announces that the United States will withdraw from the Paris climate accord, against the advice of his Secretary of State, his Secretary of Defense, and some 600 business leaders who wrote to him saying withdrawal would be bad for U.S. business. I think about the Obama Administration’s emphasis on science, technology, and evidence-based decision-making, and I have to worry that all of that will go out the window under Trump.

I’m extremely unhappy across the board with the way this administration is proceeding. My views are probably similar to those of a very substantial majority of scientists and technology experts, who by the very nature of their professions have respect for evidence rather than suspicion, rumor, and innuendo in decision-making.

What role can WHRC play in the coming years?

The Woods Hole Research Center is the pre-eminent independent climate-change research institution. The work of the center is absolutely indispensable in understanding the impact of climate change and indispensable in shaping innovative and effective solutions.

WHRC and other organizations outside the U.S. government that are involved in the global climate issue cannot reduce their efforts. Indeed, they will have to increase their efforts as Federal government support shrinks, so we can continue to increase understanding of what is happening in our environment as a result of human activities and devise and help implement appropriate solutions. All of these organizations will need to be energetic in seeking support and connecting with donors who understand the importance of this sort of work.

And we need to speak out and be in practically continuous touch with our representatives in Congress. Congress is our main hope for ameliorating what Trump is trying to do. There are members of Congress who are speaking out, including a few Republicans, saying that the Trump Administration and its enablers in the Congressional leadership need to stop ramming through massive, regressive changes in economic, environmental, and health policy without regard for due process, evidence, or analysis. We should all of us be urging Congress to restrain the worst impulses of the Trump administration. There has never been a time that being outspoken is more important.
WHRC’s Polaris Project brings a group of student-scientists to the Arctic to take part in research on climate change impacts. In 2017, the team traveled to Alaska’s Yukon-Kuskokwim Delta to study everything from changing hydrology to emissions from permafrost. After three weeks in the field, the team returned to WHRC headquarters to analyze samples and present their findings.
Thank you outgoing Board members

**John H. Adams** is the founding president of both the NRDC and the Open Space Institute, and was also instrumental in the founding of WHRC in 1984 and ’85 with Founder and Director Emeritus George M. Woodwell. Mr. Adams helped build the Board of Directors and has been a key adviser on issues of science, conservation, and institutional structure. His powerful influence on environmental science, his generosity and multiple insights have been invaluable over nearly five decades, during which time WHRC emerged to its current prominence.

**Lily Rice Hsia** is retired from Mather and Hsia, where she worked as a consultant to nonprofits - primarily environmental and educational organizations. She served on the boards and committees of the New England Aquarium, the Trustees of Reservations, Woods Hole Oceanographic Institution, and the Essex County Community Foundation. Her energy, enthusiasm, and support were particularly critical to the building of WHRC’s permanent campus in the early 2000s. She and her husband John Hsia live in South Hamilton and Cambridge, MA.

Welcome incoming Board members

**Heather Campion** brings to the WHRC board a diverse background with extensive experience in both the public and private sectors, and in higher education. Heather currently serves as a principal at Mount Vernon Strategies, a strategic consulting firm focused on reputation building and public engagement. She also serves on the board of Harvard’s Institute of Politics, where she is currently advising them on their Women’s Initiative in Leadership Program. Most recently, she was CEO of the John F. Kennedy Library Foundation, where she also served on the Board of Directors for over 10 years. Prior to that, served as an executive in the financial services sector and also held key administrative positions at Harvard University’s John F. Kennedy School of Government. Heather began her career in government and national politics, serving in the White House during the Carter Administration, and has held senior roles in several presidential campaigns. She and her husband reside in Brookline, MA and summer in Falmouth.

**Michael Fanger** has been a lifelong member of the WHRC family as a result of his mother Iris’ longtime service on the Board of Directors. In his professional life, Michael is the founder, managing member, and president of Eastern Funding, a specialty finance company focused on small and mid-sized business lending. Michael began his professional career in banking at Shawmut Bank in Boston where he ultimately served as Vice President. From 1987 to 1997, Michael was Executive Vice President at Medallion Financial Corporation in New York and President of Transportation Capital Corporation, a subsidiary of Medallion. Michael is a graduate of Colby College. He and his wife Linda Sattel and their two children live in Moorestown, New Jersey, and spend summers in Woods Hole.

**Marc E. Goldberg** brings to the WHRC board managerial and investment experience in the life science sector. Marc is co-founder and Managing Partner of BioVentures Investors, a premier med-tech investment firm. Prior, Marc served in numerous executive roles at Massachusetts Biotechnology Research Institute; Safer Inc., and Genetics Institute. Marc has served on the boards of numerous industry groups and non-profit organizations including the Massachusetts Biotechnology Council, Harvard Medical School Advisory Council on Discovery, Harvard Varsity Club, Step by Step Supportive Services, and the Richi Childhood Cancer Foundation. Marc earned his B.A. from Harvard College, his J.D. from Harvard Law School, and his M.B.A. from Harvard Business School. He and his wife live in Wellesley, MA.
Incoming Board Members cont.

**Joseph J. Mueller** is recently retired as the founder and an owner of Rockport Mortgage, a leading national provider of multifamily and healthcare financing solutions. Early in Joe’s career, he was an economist for NOAA Fisheries, where he worked closely in the late 1970s on building mathematical models of the East Coast fisheries for assisting in policy deliberations. He then founded a software company, which he subsequently sold, and started Rockport Mortgage. Joe recently cycled off the Board of Directors at Rockport Music Group, after serving as Board Chair and Co-Chair of two capital campaigns: a $20M campaign to build the Shalin Liu Performance Center and a $12M endowment campaign. He also served on the boards of Reforest the Tropics, Wellspring, and the St. Ann’s School. Joe has a B.S. in Economics from St. Louis University and an M.S. in Economics from Cornell University. He and his wife Eileen live in Rockport, MA.

**Georgia Chafee Nassikas** is a passionate environmentalist and is thrilled to bring her diverse experience in the art and non-profit worlds to the WHRC Board. Georgia is an artist who works in encaustic, a medium using damar, pigment, and beeswax from her hives. In her volunteer life, she serves on the Boards of the Potomac Conservancy, Island Press, the McLean Project for the Arts, and St. Mark’s School, as well as on the Advisory Board of the Amazon Conservation Association. She is a member of the Garden Club of America and serves on the flower guild of the National Cathedral. Georgia’s interest in and commitment to science and the environment came to her at a young age, greatly influenced by her father, the late US Senator John H. Chafee. She and her husband live in McLean, VA.

**Stephanie Tomasky** is an Emmy Award-winning documentary producer, director, and writer and has over 20 years experience producing for HBO, NBC, A&E and the History Channel. Stephanie has always believed in the power of media and storytelling for social change and in keeping with this she has used her skills to produce and help raise funds for the sciences, including The San Francisco General Hospital Foundation and The Institute for Global Orthopaedics & Traumatology. She has also used her talents to help raise awareness and funds for important local and global causes. Stephanie comes to the WHRC with the unique perspective of a documentarian and is eager to use her energy and skills to help tell the story of the important science and policy initiatives of WHRC. Stephanie and her husband, Mitch, along with their 11-year-old daughter, Ava, and 2 dogs, currently live in Boulder and Telluride, where they are enamored with the beauty of and acutely aware of the threats posed by climate change to the natural beauty and lifestyle of the intermountain west.

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**The President’s Council**

The President’s Council is a non-governing group of loyal friends who contribute their time and expertise to provide advice and counsel to the Center’s President and Staff on a variety of strategic, programmatic, and managerial topics. We thank them for their support.

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# Statement of Activities

## 2016/2017 Report

### Support and Revenue

<table>
<thead>
<tr>
<th>Without Donor Restrictions</th>
<th>With Donor Restrictions</th>
<th>Total 2017</th>
<th>Total 2016</th>
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<tbody>
<tr>
<td>Contributions, grants, and contracts</td>
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<td>U.S. Government</td>
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<td>Foundations and other</td>
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<td>Investment income (loss)</td>
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<td>$568,403</td>
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<td>Donated equipment</td>
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<td>In-kind donations</td>
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<td>Change in value of split-interest agreements</td>
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<tr>
<td>Other income</td>
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<tr>
<td>Net assets released from restrictions</td>
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<td>(6,757,148)</td>
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<td><strong>Total support and revenue</strong></td>
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<td>1,096,213</td>
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### Expenses

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<td>Research programs</td>
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<td>$6,073,492</td>
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<td>General and administrative</td>
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<td><strong>Total expenses</strong></td>
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### Change in net assets

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<th>Total 2016</th>
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<tr>
<td><strong>Change in net assets</strong></td>
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### Net assets

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<th>Total 2016</th>
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<tr>
<td>Beginning of year</td>
<td>$6,785,737</td>
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<td><strong>End of year</strong></td>
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</table>
Fiscal Year 2017 Highlights

Fiscal 2017 was one of the soundest in recent history for WHRC, led by strong fundraising with a significant increase in Individual and Foundation support, both with and without Donor restrictions. Add in Management control of expenses and a robust financial market and the results are clear. The fiscal year closed with the Woods Hole Research Center receiving another unmodified audit opinion with no findings or questioned costs from the external audit firm of Calibre CPA Group. This report is critical to our continued success in receiving both government and private institution funding, and continues to speak to the integrity and professionalism of the Center as a whole.

The Center’s Financial Position is increasingly solid with all market ratios moving in a positive direction. Both our Net Assets without Donor Restrictions and Total Net Assets increased by $1.3M and $2.4M respectively, and our Liabilities continue to decrease.

The Center received new funding from both Foundations and the U.S. Government, both of which were up over the 2016. Support from Contributions, Grants and Contracts increased 20% from $8.5M to $10.2M excluding investment activity, while Contributions Without Donor Restrictions increased by 40%.

Research Program activity increased a healthy 9% over the prior year with the addition of new scientific support staff. Heading into 2018, The Center is well-positioned for the year ahead both financially and scientifically.

Full financial statements are available at: www.whrc.org/home/financials

<table>
<thead>
<tr>
<th>Assets</th>
<th>2017</th>
<th>2016</th>
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</thead>
<tbody>
<tr>
<td>Current Assets</td>
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<td></td>
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<tr>
<td>Cash and cash equivalents</td>
<td>$3,528,261</td>
<td>$1,788,115</td>
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<tr>
<td>U.S. Government contributions receivable</td>
<td>641,438</td>
<td>662,223</td>
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<td>Other contributions, grants, contracts receivable</td>
<td>1,316,391</td>
<td>1,344,730</td>
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<td>Prepaid expenses and other receivables</td>
<td>254,459</td>
<td>203,161</td>
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<tr>
<td>Total current assets</td>
<td>5,740,549</td>
<td>3,998,229</td>
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<tr>
<td>Investments</td>
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<tr>
<td>Endowment and quasi-endowment investments</td>
<td>5,253,923</td>
<td>4,877,532</td>
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<td>Other investments</td>
<td>1,200,777</td>
<td>1,010,924</td>
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<td>Total investments assets</td>
<td>6,454,700</td>
<td>5,888,456</td>
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<tr>
<td>Net property and equipment</td>
<td>5,762,894</td>
<td>5,993,761</td>
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<tr>
<td>Other assets</td>
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<tr>
<td>Other contributions receivable, net of current portion</td>
<td>25,000</td>
<td>102,439</td>
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<td>Beneficial interest in real estate trust assets</td>
<td>212,651</td>
<td>212,651</td>
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<tr>
<td>Bond proceeds held in trust for debt retirement</td>
<td>16,009</td>
<td>17,141</td>
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<tr>
<td>Total other assets</td>
<td>253,660</td>
<td>332,231</td>
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<tr>
<td>Total assets</td>
<td>$18,211,803</td>
<td>$16,158,677</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Liabilities and Net Assets</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Current liabilities</td>
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<tr>
<td>Accounts payable</td>
<td>$357,365</td>
<td>$335,539</td>
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<td>Accrued expenses</td>
<td>419,004</td>
<td>276,631</td>
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<td>Liability under charitable gift annuities</td>
<td>7,954</td>
<td>9,798</td>
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<td>Refundable advances</td>
<td>30,719</td>
<td>13,143</td>
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<td>Loan payable</td>
<td>289,192</td>
<td>394,192</td>
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<td>Total current liabilities</td>
<td>1,104,234</td>
<td>1,029,303</td>
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<td>Long-term liabilities</td>
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<tr>
<td>Liability under charitable gift annuities, net of current portion</td>
<td>77,715</td>
<td>102,898</td>
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<tr>
<td>Loans payable, net of current portion</td>
<td>1,497,449</td>
<td>1,892,780</td>
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<td>Total liabilities</td>
<td>2,679,398</td>
<td>3,024,981</td>
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<tr>
<td>Net assets</td>
<td></td>
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<tr>
<td>Without donor restrictions</td>
<td></td>
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<tr>
<td>Operating</td>
<td>3,561,283</td>
<td>2,583,319</td>
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<td>Board designated endowment</td>
<td>532,488</td>
<td>532,488</td>
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<tr>
<td>Net investment in property and equipment</td>
<td>3,992,262</td>
<td>3,669,930</td>
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<tr>
<td>Total net assets without donor restrictions</td>
<td>8,086,033</td>
<td>6,785,737</td>
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<tr>
<td>With donor restrictions</td>
<td></td>
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<tr>
<td>Temporary restrictions</td>
<td>3,755,193</td>
<td>2,658,980</td>
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<td>Perpetual restrictions</td>
<td>3,691,179</td>
<td>3,688,979</td>
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<tr>
<td>Total net assets with donor restrictions</td>
<td>7,446,372</td>
<td>6,347,959</td>
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<tr>
<td>Total net assets</td>
<td>15,532,405</td>
<td>13,133,696</td>
</tr>
<tr>
<td>Total liabilities and net assets</td>
<td>$18,211,803</td>
<td>$16,158,677</td>
</tr>
</tbody>
</table>
We are deeply grateful to the individuals, foundations, and businesses listed on the following pages who supported us through gifts and pledges made during the Center's fiscal year July 1, 2016 - June 30, 2017.

$100,000+
Charles R. O'Malley
Charitable Lead Trust
Foundation for the Carolinas
Harbourton Foundation
Christopher and Lisa Kanef
Francis and Victoria Lowell
Wilhelm Merck and Nonie Brady
Kristie Miller
Amy and James Regan
Joseph and Marilé Robinson
Ruth McCormick Tankersley
Charitable Trust
Fred and Alice Stanback

$50,000-$99,999
Anonymous (2)
Borrego Foundation
Moses Ginsberg Family Foundation
Pisces Foundation
Wallace Global Fund

$25,000-$49,999
Endurance Foundation
Spencer Glendon and Lisa Tung
Jeremy and Hannelore Grantham
The Grantham Foundation for the Protection of the Environment
Benjamin and Ruth Hammett
David Hoover and Carol Swenson
Monique Luzzì
Ted and Connie Roosevelt
Sant Foundation
Whalesback Foundation

$10,000-$24,999
Garrett Albright
ARIA Foundation
Stephen Bernier
Phyllis Bock
John and Nancy Braitmayer
Anita Brewer Siljeholm
Cogan Family Foundation
John Cogan and Mary Cornille
Michael Fanger and Linda Sattel
Hart and Nancy Fessenden
Rick Gill and Betsy Jewett
Carol R. and Avram J. Goldberg
Deborah B. Goldberg
Joshua R. Goldberg
Stuart Goode and Nancy Cooley
Serena Hatch
Timothy and Joan Ingraham
J. Atwood and Elizabeth Ives
Katharine Merck
John and Georgia Nassikas
Joseph and Eileen Mueller
MF Bartol
Charitable Giving Fund

$1,000 - $4,999
Anonymous (2)
Ayci Charitable Foundation
Robert and Alison Ament
Michael and Margherita Baldwin
Rhoda Baruch
Robert and Pam Beck
Benjamin Family

Anthony Bernhardt
Bonnie Ward Simon Foundation
Ed and Amy Brakeman
David Brown and Nawrie Meigs Brown
Bunbury Fund of the Princeton Area Community Foundation, Inc.
James Clemans
Community Foundation for Greater New Haven
Mitchell Cohen and Stephanie Tomasky
Michael and Marcia Corrigan
Robert and Sylvia Dickinson
Leonard and Armamarie DiLorenzo
Vivian Donnelley
Philip Duffy and Lauren Kass Duffy
Ed and Susan Epes
Thomas and Diane Esserman
Esther Simon Charitable Trust
Delia Flynn
Michael and Lianne Foley
Geoffrey Freeman and Margorie Findlay
Georgia Hume Evans Memorial
Timothy and Mary Helen Goldsmith
Lorna Grenadier
Jane Hallowell
Harborage LLC
Peter and Karen Hargraves
George and Marina Hatch
Whitney and Elizabeth Hatch
Mary and Harry Hintlian
Art and Eloise Hodges
Richard and Susan Houghton
Robert and Marion Howard
Gordon and Elizabeth Hughes
Robert and Margaret Huskins
Frank and Judith Kauffman
Lester and Kathy Kretman
Marta Jo Lawrence
Carl and Joanne Leaman
Noëlle and Bill Locke
Thomas Lovejoy
R.J. and Leslie Lyman
Sheila Manischewitz
Harriet Meiss
Michael and Dudley del Balso Charitable Trust
Charles and Mary Lou Montgomery
Abigail Norman
Normandie Foundation
Joan Person
Eugene and Diana Pinover
Stephen Pomerance
Dick Raines

David and Laurie Reed
Tedd and Ella Saunders
Bonnie Simon
Strachan Donnelley
2003 Charitable Trust
Gerald and Mary Swope
Trustees of Oregon Episcopal School
Twin Chimney Inc.
Frederica Valois
Nina Webber
Helmut and Caroline Weyman
George and Katharine Woodwell
Redwood* and Mary* Wright
Roe Zweig and Christin Rawley

$500 - $999
Anonymous (1)
John and Patricia Adams
Charles and Christina Bascom
Michael and Eryn Bingle
Elizabeth Bunnen
David and Colleen Burt
Charles and Heather Campion
Bonnie Clendenning
Climate Ride, Inc.
Thomas and Ann Cox
Molly N. Cornell
Murray and Judith Danforth
Lawrence and Regina DelVecchio
Nicholas and Bitten Dill
Annie Dillard and Bob Richardson
Julian Draz
Frank Dunau and Amy Davis
Elizabeth & Frank Odell Family Fund of the Community Foundation of Collier County
Dorothea Endicott
Gilbert Verney Foundation
Antoine and Sandra Hadamard
Melinda Hall and Lawrence Pratt
Charles and Ethel Hamann
Max and Gabby Holmes
David Isenberg and Paula Blumenthal
Lawrence and Ginette Langer
Whitney and Phillip Long
Lubo Fund
Kai and Marion Marcucelli
Jay and Rebecca Markley
Josephine Merck
Ruth I. Morton
Tom and Carol Odeh
Penny and Ted Thomas Fund of the Princeton Area Community Foundation, Inc.

Canopy  Fall 2017  24
In May 2017, Board members and WHRC friends traveled to Tanguro Ranch in Brazil to see first-hand how the challenges of managing global climate change, in the face of needing to feed a growing world population, are being studied and addressed by WHRC scientists and their colleagues.
In October 2017, scientists of the Global Rivers Observatory embarked on a river expedition to the Columbia & Snake rivers in the Pacific northwest aboard the 32-passenger MV Island Spirit. Guests were invited to work alongside an international team of GRO scientists as they develop projects and collected samples; participated in evening discussions and presentations; and took side trips to explore both natural and engineered areas along the rivers.
George Perkins Marsh Society

The Society recognizes friends who have elected to partner in the Center’s future to help sustain human prosperity and a verdant Earth for generations to come through a life income gift, annuity, life insurance policy, or bequest. The Society honors the legacy of George Perkins Marsh, who first drew attention to the idea that the real menace to nature is caused by humans themselves. Born in 1801, Marsh published the book Man and Nature in 1864, still widely considered a pivotal text in the founding of the conservationist and environmental movements.

Society members

Dolores Arond
Sharon Bidwell
Denny Emory
Iris and Robert Fanger
Scott Goetz and Nadine Laporte
Ben and Ruth Hammert
David Hoover and Carol Swenson
Frank and Judith Kaufman
Joan Person
David and Edith Ross
E. Andrew Wilde
George and Katharine Woodwell

In Memoriam

Donald Bidwell
Warren Felt
Martin Person
Redwood and Mary Wright

Gifts In Honor Of

Abby, Sam, Maddie and Jed from Leon and Joanne Malkin
James H. Adams, Jr. from David Adams
Nathan Baskin from Lorna Cagann
Foster Brown from Richard Sailor and Mary Johnston
Stuart and Joanna Brown from Dave Wedley
Jacqueline Carlsten from Cathleen Cordaro
Philip Duffy from Richard and Susan Houghton, Kirstin Moritz and Rod Hinkle

Matching Gift Organizations

Amgen Foundation
Colgate Matching Gift Program
FM Global Foundation
Ford Foundation
GE Foundation
JLL Community Connections
Microsoft Matching Gift Program
New Balance Athletic Shoe, Inc.

Canopy Fall 2017 27
As a lifelong conservationist, I have watched with dismay as our common heritage of natural communities has been degraded, and rejoiced at the opportunity to be a force for protection and restoration of riparian and natural landscapes. From an internship cleaning fish tanks at Steinhardt Aquarium in San Francisco to years later drafting the San Francisco Bay Delta Estuarine Management Plan for EPA, the importance of clean and abundant water has been an interest and theme in my life. The land trust that I helped found here in Eastern Washington has focused on the shorelines of lakes, rivers, and streams for the past quarter century. Clean water is our lifeblood.

Realizing the seriousness of global warming a number of years ago, Rick and I sought to support organizations that help the world address climate change. Woods Hole Research Center stood out for the excellence of their research documenting changing ecosystems impacted by climate change. We have been thrilled at WHRC’s designation of being ranked the world’s #1 climate change think tank over the past four years and are happy to support their groundbreaking work.

Years of involvement in protecting the rivers of the western US made us jump at the opportunity to join the WHRC-WHOI Global Rivers Observatory expedition cruising on the Columbia and Snake rivers this past October. What we learned from our fellow travelers and research scientists working on rivers all over the world highlighted the challenges and furthered our commitment to the protection of our natural ecosystems that sustain all of life.

Betsy Jewett and Rick Gill
Nine Mile Falls, WA
10 Things to Know About Climate Change

There is no real scientific debate about climate change. A 2016 review showed that at least 97 percent of actively publishing climate scientists agree climate change is happening and is extremely likely caused by human activities.

A large majority of the United States (70%) understands climate change is real and is caused by human activity, including 60% of Republicans.

In 2015, only half of the U.S. Senate had publicly acknowledged human caused climate change.

We are making progress. Greenhouse gas emissions in the US have shrunk by 16% in the past decade, in part due to the availability of renewable energy.


Climate change is not a future problem. We are already seeing impacts from climate change, including flooding from rising sea levels, extreme weather, and wildfire.

In October 2016, the generating capacity of renewable energy systems around the world surpassed that of coal power, which is the most harmful of the fossil-fuel based energy sources.

Forests have the capacity to pull massive amounts of carbon out of the atmosphere. In fact, storing carbon in forests and soils is the only “technology” that is available immediately to provide negative emissions at the scale needed to avoid the worst effects of climate change.

You have the power to help address climate change. Learn about some easy ways that you can help: whrc.org/how-you-can-help

It’s not too late. If we take action now, we can still avoid the worst-case scenarios of climate change impact.

Learn how you can directly support climate science research at WHRC

Alison Smart
Chief Development Officer
508-444-1545 asmart@whrc.org

Beth Bagley
Director of Annual Giving
508-444-1517 ebagley@whrc.org
Sarah “Ludda” Ludwig and Christina Minions complete setup of a station designed to measure carbon dioxide fluxes from soil, along with soil temperature and moisture, continuously over the Alaskan winter.