MAPPING THE WAY
TO A SUSTAINABLE FUTURE

Woods Hole Research Center

Advancing Science. Informing Solutions.

Woods Hole Research Center

Our Mission

To advance scientific discovery and seek science-based solutions for the world's environmental and economic challenges through research and education on forests, soils, air and water.

Our Challenge

The climate is changing at an unprecedented rate in human history: tropical forests are being cut, freshwater resources are at risk, and biological diversity is declining. We know how to reverse these trends, but it will be the great challenge of our generation to sustain prosperous and meaningful life experiences for 7 to 10 billion people while stewarding the climate, forests, soils, air, and water upon which life depends.

Our Vision

A world in which the insights of science guide management of the Earth's natural resources, so that we and future generations may sustain prosperous and fulfilling lives without degrading the ecosystems that support humanity and a diverse abundance of life.

Photo at right: The Woods Hole Research Center's Gilman Ordway Campus, in Falmouth, Massachusetts, is a model in its use of energy, water, and environmentally-friendly building materials. An integrated design-build approach achieved very high core efficiencies by employing a super-insulated building envelope, high-performance glazing, energy recovery ventilation, low energy use lighting, and other efficiency strategies. Via the wind turbine and a rooftop photovoltaic system, the Center produces more than half its required energy.

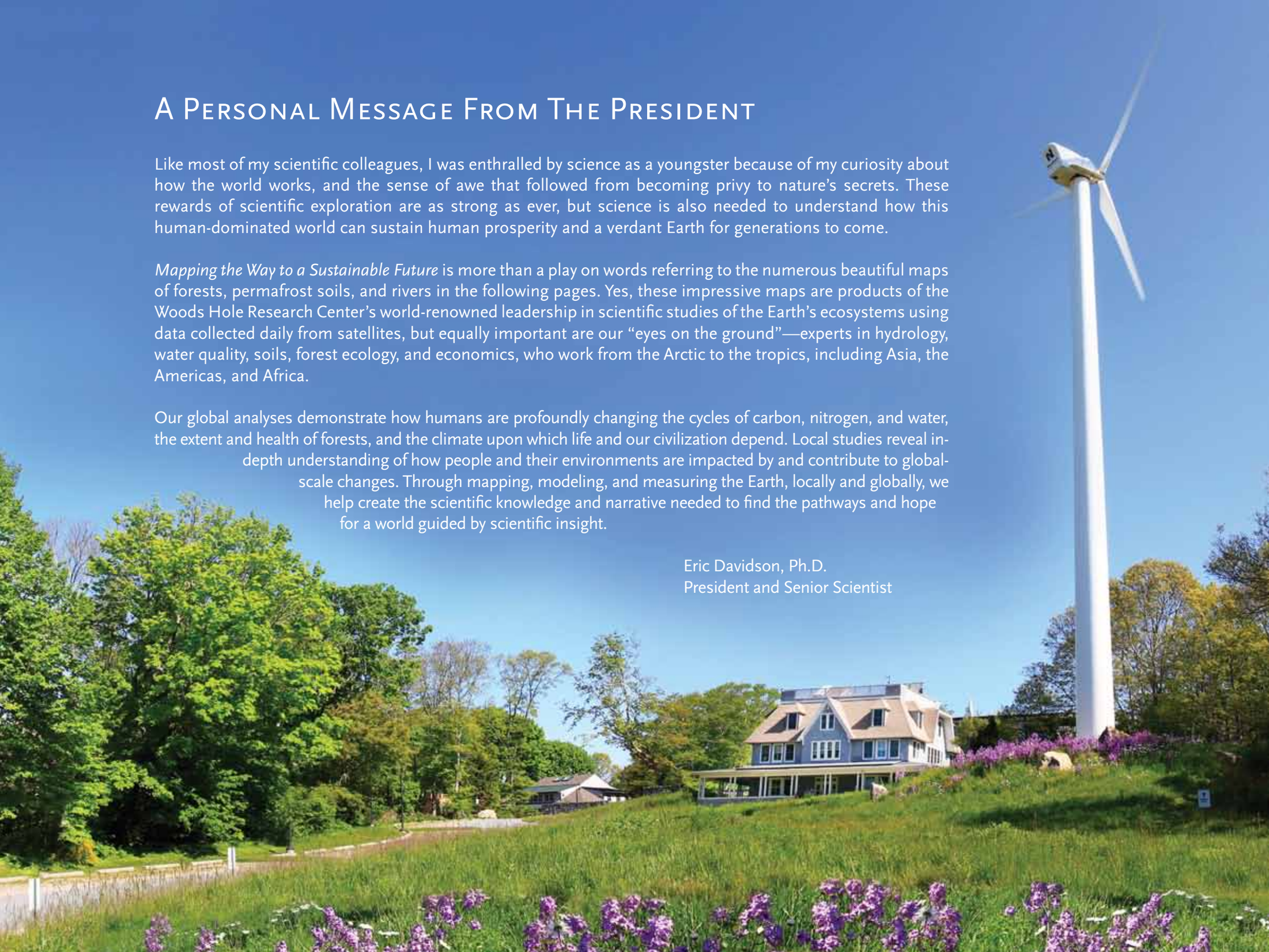
A Personal Message From The President

Like most of my scientific colleagues, I was enthralled by science as a youngster because of my curiosity about how the world works, and the sense of awe that followed from becoming privy to nature's secrets. These rewards of scientific exploration are as strong as ever, but science is also needed to understand how this human-dominated world can sustain human prosperity and a verdant Earth for generations to come.

Mapping the Way to a Sustainable Future is more than a play on words referring to the numerous beautiful maps of forests, permafrost soils, and rivers in the following pages. Yes, these impressive maps are products of the Woods Hole Research Center's world-renowned leadership in scientific studies of the Earth's ecosystems using data collected daily from satellites, but equally important are our "eyes on the ground"—experts in hydrology, water quality, soils, forest ecology, and economics, who work from the Arctic to the tropics, including Asia, the Americas, and Africa.

Our global analyses demonstrate how humans are profoundly changing the cycles of carbon, nitrogen, and water, the extent and health of forests, and the climate upon which life and our civilization depend. Local studies reveal in-depth understanding of how people and their environments are impacted by and contribute to global-scale changes. Through mapping, modeling, and measuring the Earth, locally and globally, we help create the scientific knowledge and narrative needed to find the pathways and hope for a world guided by scientific insight.

Eric Davidson, Ph.D.
President and Senior Scientist



The Climate Change Challenge

Along with the burning of fossil fuels, the loss of forests from deforestation accounts for a significant amount of all carbon dioxide released into the atmosphere from human activity. These emissions trap the sun's energy near the Earth, which not only makes the planet warmer, but also accelerates storm-generating energy. The resulting extreme weather events, floods and droughts are already putting our food and water supply, health and economic prosperity at grave risk.

To combat these threats to our planet, WHRC is on the ground in more than 15 countries around the world conducting scientific research while training local governments and communities how to measure the carbon contained in their forests. Whether it's trekking through mud and water in the Congo, or negotiating the treacherous slopes of a bamboo forest in Southeast Asia, WHRC scientists are determining which forests have the greatest potential for preserving carbon, as well as the wildlife and human communities within them. Along with satellite imagery, field data show us why forests are so important for the maintenance of climate and life. And the resulting carbon maps also serve as important tools to help local communities receive financial compensation for alternative agricultural methods that minimize forest destruction.

The burning of fossil fuels—gas, coal and oil, is the largest source of heat trapping gas emissions.

John Poulsen

WHRC GIS manager Greg Fiske and postdoctoral researcher Dr. Paul Mann collect water samples in the Congo River watershed.

Piloting Policy

As part of an international effort to address climate change under the UN Framework Convention on Climate Change, WHRC played an active role in the development of the Kyoto Protocol, which was adopted in 1997. The Center's work then focused on effective implementation of the various guidelines and mechanisms associated with the Protocol. Even as the final details of the Kyoto Protocol were being negotiated, the Center began to turn its attention to another facet of the climate change mitigation discussion—how to help developing countries slow their rates of tropical deforestation and thus reduce the magnitude of carbon emissions resulting from forest loss and land use change.

Left: This image shows deforestation for the development of a palm nut oil plantation. The roads give access to loggers and palm nut processing companies. Together with deforestation and subsequent fires, this series of events greatly exacerbates climate disruption.

Aron Stubbins

The Arctic Carbon Bomb

Arctic ecosystems have experienced some of the most dramatic warming in recent decades. This has produced visible thawing of the Arctic's permafrost soil, releasing much of the carbon that has been buried within the soil since before the dawn of civilization, further contributing to climate change. Feeding on itself, this warming also produces a significant increase in wildfires, which then causes the release of even more carbon.

The resulting "Arctic bomb" could release 100 billion tons of carbon into the atmosphere by 2100 and greatly impact the global climate system.

WHRC scientists are using satellite imagery and field measurements in Alaska and Northeastern Siberia to determine how the release of this carbon will affect climate change. By studying the effects of warming on the permafrost under different types of vegetation and topographies, we are gaining insight into the amplified impacts of climate change at high latitudes. In addition we are researching the largest Arctic rivers to understand how increasing river flow, driven by global warming, will influence ocean circulation and climate. Using chemical analyses of river water, our scientists are also able to diagnose changes in upstream forests and soils. This information tells us more about climate change in the Arctic and around the globe.

One of the many visible consequences of climate change, polar bears face extinction with the melting of Arctic sea ice.

What's Soot Got To Do With It?

It may come as a surprise, but one of the quickest ways to slow climate change is to reduce soot. That's because as much as one third of recent glacier thinning can be attributed to deposits of this black carbon, which causes glaciers to absorb more sunlight and melt faster. Referred to as one of the "low hanging fruits" of climate change solutions, it is feasible to control black carbon in the near term.

With this in mind, WHRC scientist Robert Spencer has journeyed to the mountains of Tibet and remote areas of Alaska to collect glacial samples. By studying the rate of black carbon accumulation, WHRC is helping policymakers understand the importance of slowing climate change and glacial melting.

Opposite: Hikers traverse the Mendenhall Glacier in Alaska where WHRC scientists have been studying the effects of soot fallout.

Deforestation in the Amazon

The Amazon Basin is the world's largest river system, covering more than 6.65 million square kilometers. In this naturally-colored satellite image forested areas appear green, while savannas, mountain woodlands and barren Andean highlands appear in lighter tones. Deforested areas are shown in yellow. Important rivers are shown with dark blue lines and areas of seasonal flooding are in dark blue shading. Maps like these help us understand the trends in agricultural and infrastructure development and how they are influencing the climate and hydrology of the Amazon.

WHRC science has helped fishing communities in the lower Amazon develop a sustainable lifestyle.

The Amazon Basin

The Brazilian Amazon is one of the world's most iconic landscapes, but also one of its greatest conservation challenges. Presenting an environmental and socio-economic picture of what society needs to consider—how do we balance human and natural ecosystem demands—this equatorial environment is home to nearly one fifth of the planet's plant and animal species, more than 200 indigenous cultures and 30 million people in search of sustenance and prosperity.

Seen through the eyes of science, the Amazon has the carbon equivalent of more than a decade's worth of global fossil fuel emissions stored in the wood of its trees, and its forest releases enough water into the atmosphere via photosynthesis and to the ocean via river flow to influence world climate and ocean circulation systems.

Deforestation in Brazil, driven in large part by increased global and regional demand for food and fuels, has been reduced in recent years from the very high rates of the early 2000s, but the ecological and social consequences continue, and maintaining these low rates into the future will be difficult. Through studies on the drivers of deforestation, local resource governance, aquatic and terrestrial ecosystems functioning, and human influences on climate, WHRC is developing a broad and thorough understanding of how this key ecosystem operates, how it is being modified by human action and how we can promote sustainable use of the forest.

Wayne Walker

Chris Linder

Dan Nepstad

Wayne Walker

Empowering Indigenous Communities to Protect Forests

In the humid Amazon rainforest where deforestation is responsible for a significant amount of the world's carbon emissions, WHRC scientist Wayne Walker drives a tall wooden stake into the ground. Indigenous leaders from local villages watch closely as he wraps a brightly colored flag to the top of the stake.

Dr. Walker hands one person a compass. To a second, he gives fiberglass tape. It's their turn now.

These men and women aren't just learning how to measure the amount of carbon contained in their trees—they're being empowered to prevent outsiders from exploiting their forests.

Armed with the ability to make informed decisions about how best to monitor and manage their forests, indigenous peoples together with the governments of tropical nations are working to establish mechanisms to compensate local communities for reducing carbon emissions from deforestation and forest degradation. Such efforts are critical to slowing climate change due to the fact that tropical forests store massive amounts of carbon in their leaves, branches, stems, and roots.

"These forests are essential to the survival of people, the rich wildlife they host and to stabilize our climate. If we really want to save these forests and reduce carbon emissions from deforestation, then everyone has to be a part of it."

Dr. Nadine Laporte,
Associate Scientist

Supporting the Protection of Wildlife Habitat

Deforestation not only devastates human communities, but wildlife habitat as well. And when wildlife habitat suffers, so too does the soil, air and water we depend on for wellbeing and prosperity. The Congo Basin for example, which contains the second largest block of tropical forest in the world, is also home to endangered great ape species such as bonobo (*Pan panicus*), found only in the Democratic Republic of Congo. Increasing deforestation from logging and mining is threatening the survival of great apes—only 12% of Congo Basin forests are protected. In the Republic of Congo, WHRC and the Lincoln Park Zoo partnered to conduct a study to document the impact of logging on gorilla and chimpanzee habitats and to use the information to influence forest policies for better conservation.

Seeing REDD+

As forests are cleared for timber production, cattle ranching and industrial agriculture, indigenous communities risk losing their homes, livelihoods, traditional ways of life and cultural identity. Reducing Emissions from Deforestation and Forest Degradation (REDD+) is a United Nations program that creates a financial value for the carbon stored in forests. Instead of having their forests converted to agriculture or cut for timber, developing nations are compensated by more industrialized nations in North America and Europe for preserving their forests. Scientists at WHRC train governments and indigenous groups to monitor their own forests for carbon, a vital ingredient for the success of emissions-reduction programs such as REDD+. **Your gift will support climate change science, and help indigenous communities work toward a secure future.**

Opposite page: The Amazon forest extending east of Puyo, Ecuador. Top left: A community member collects field data in the Amazon. Top center: Community members do field work in the Congo. Top right: Dr. Wayne Walker teaches data collection techniques to an Amazon community.

The Need for Science Based-Solutions

Serving the Public Good

The idea that science benefits society and serves the public good is one of the founding principles of our society. In that spirit, Woods Hole Research Center tirelessly advances science and knowledge as one of society's most important assets. Yet tragically, many decisions made by policymakers today often ignore the solutions that science provides.

That's why your support of WHRC's world-class research is so important. Together we can advance the development of scientific insights that empower future generations and policymakers to make informed, innovative decisions pertaining to some of the most challenging environmental and economic issues facing our planet today.

Just as important as conducting the actual research however, is the need to clearly communicate the results to key decision-makers and managers so they will be better able to deal with the issues confronting them. In a time when the value of science itself is often questioned, we must promote scientific discovery as an important tool while also sharing its findings. To this end our work is regularly published in national reports and peer-reviewed scientific journals such as *Nature*, as well as in popular media such as *Forbes* and *The Economist*, and broadcast on television and radio.

Your gift will help us advance science-based solutions to better manage the Earth's natural resources.

"When I try to distill my motivation of why I do science, it comes down to influencing people and their decisions about how we use the planet. If the knowledge produced were not to reach people who make decisions, much of the value of what I do would be lost."
Dr. Foster Brown, Senior Scientist

Villagers plant potatoes in a field near Volcanoes National Park in Rwanda.
WHRC trains communities like this one to monitor their forests.

Wayne Walker

Overcoming the Nitrogen Challenge

While slowing climate change focuses mainly on reducing carbon dioxide emissions, there's another element that is often overlooked when it comes to a wide range of environmental and human health issues—excess nitrogen. Humans have more than doubled the amount of usable reactive nitrogen in the Earth's terrestrial ecosystems each year through the use of fertilizers and the combustion of fossil fuels. This is a serious problem for many reasons.

From increased ozone levels that lead to pollution-related respiratory illnesses, to the contamination of drinking water and the destruction of surface waters from algae blooms, excess reactive nitrogen has tremendous negative impacts. At the same time, soils in many parts of the world such as sub-Saharan Africa have lost their nitrogen due to erosion and local farmers cannot afford fertilizers.

So how can we produce the food we need while maintaining a healthy nitrogen cycle?

WHRC research on nitrogen is a vital first step to creating policies that facilitate food production with less pollution. By monitoring and analyzing the behavior and impacts of reactive nitrogen in the environment, we are able to inform solutions that take into account all of the complex environmental, human health and economic factors. Effective policy is impossible without the knowledge that scientific research produces.

Your gift to WHRC can help us find solutions to manage nitrogen wisely, so that it supports productive agriculture while causing minimal harm to ecosystems and human health.

Nitrogen in the form of fertilizer is needed to produce the world's food, but too much nitrogen harms the environment. WHRC science charts the way through this and similar challenges.


Alessandro Baccini


Sebastião Aviz do Nascimento


Alessandro Baccini

This mixed tundra and boreal forest view near Denali National Park shows the type of terrain in which WHRC scientists study burned areas to assess their role in carbon sequestration by vegetative regrowth. They do so by examining satellite vegetation images and collecting field data. Top left photo: Three members of the Ruhengeri community in Rwanda collect biomass field data after being trained by WHRC scientists. Top center: WHRC research associate Paul Lefebvre collects soil samples in the Mato Grosso region of the Amazon. Top right: Bolivian community leaders learn to track biomass in their forests.

Advancing Science. Informing Solutions.

Around the World

We would like to share with you a sampling of Woods Hole Research Center programs that showcase our research on forests, soils, air and water around the world. With over 30 projects, WHRC scientists are constantly advancing scientific discovery while helping to create science-based solutions to the planet's most challenging environmental and economic issues.

Sustainable Management

Challenge: Fisheries are the main source of animal protein and income for thousands of Amazon River communities, but many species have been depleted due to overfishing and habitat degradation.
Response: Through research, training, and policy formulation, WHRC is helping communities sustainably manage floodplain resources.

Scientific Discovery

Challenge: The greatest warming from climate change can be found in the Arctic, which has a tremendous impact on the global climate system.
Response: WHRC scientists are studying the rapidly developing impact of climate disruption on Arctic watersheds, permafrost and wildfires in order to demonstrate the urgent need to reduce use of coal, oil, and gas throughout the world.

Map & Dataset Production

Challenge: Environmental planners need to know how much forest we have and where it lies in order to conduct sound management of forest resources, including water, soil and timber. Land use planners also need to be able to monitor loss of farmlands and wildlife habitat due to urban sprawl.
Response: WHRC produces maps and data to help track landscape change to support decision making on Cape Cod and throughout the world.

Facilitating Forest Research

Challenge: The growing needs for food security, economic growth and investment are creating the potential for rapid deforestation.
Response: WHRC is initiating a project in the Democratic Republic of the Congo to facilitate forest research and educate future generations of Congolese scientists and government officials on how to best protect the world's second largest rainforest by guiding where and how agriculture takes place.

Capacity Building

Challenge: Tropical deforestation, accounting for approximately 15% of all carbon emissions, increases the rate of climate change.
Response: The government of Indonesia has invited WHRC to assist with identifying and mapping which areas that have already been deforested are most suitable for agriculture, which should be allowed to grow back as forest, and which standing forest areas are most vulnerable to future deforestation. This is an example of transferring knowledge and skills about carbon mapping and landscape planning to countries engaged in international efforts to slow deforestation.

Modeling Large Watersheds

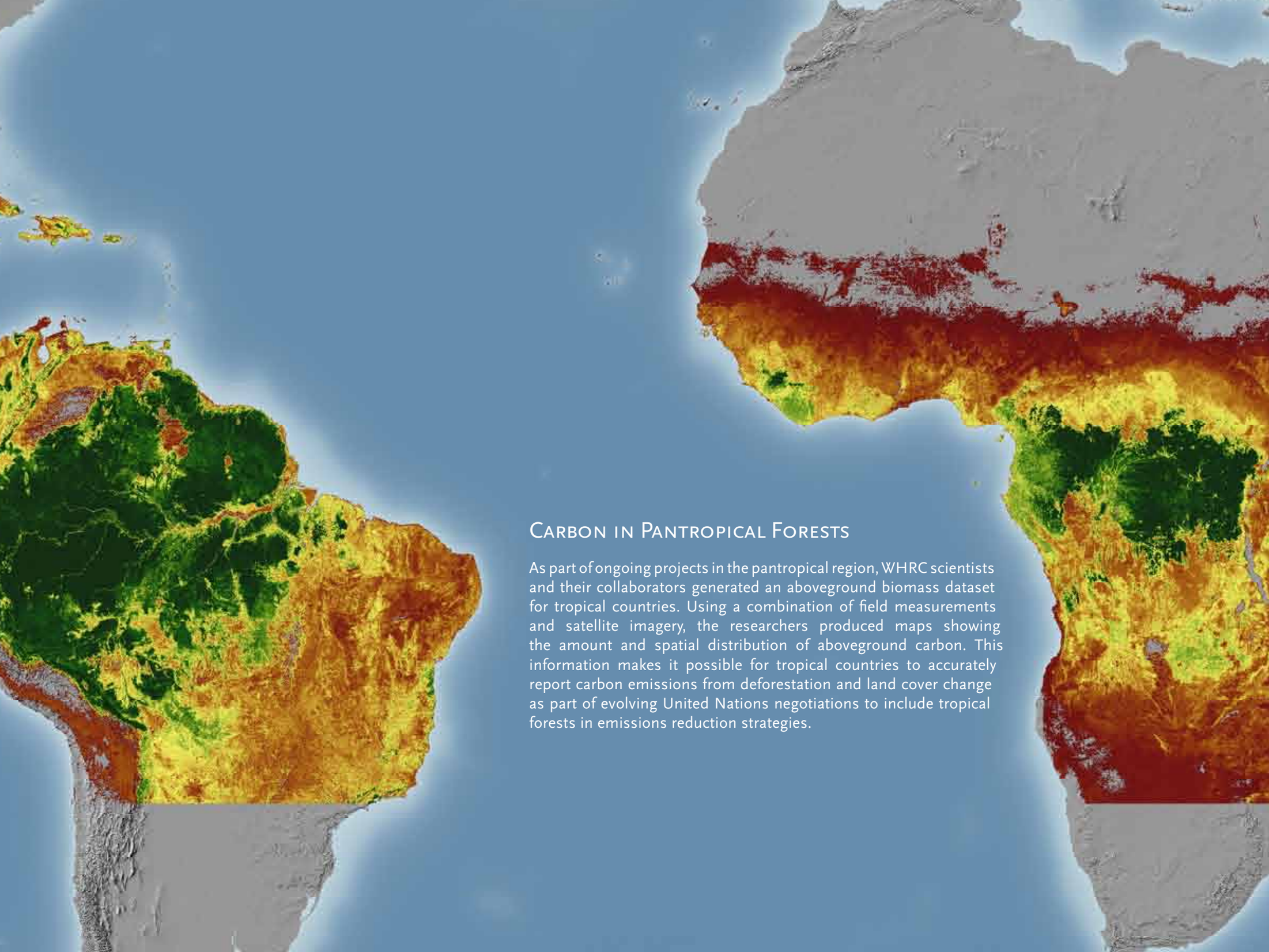
Challenge: Climate and land use changes, and the associated feedbacks between these two worldwide human impacts, are causing changes to the coupled global carbon, energy and water cycles.
Response: We are monitoring, mapping and modeling large watersheds to quantify the causes and consequences of human land use and climate changes. Applying our tools gives us the best integrated measure of the current fluxes of water and carbon from large landscapes and an understanding of how human changes to the climate and terrestrial environment are leading to future destabilization of arctic and tropical forest environments.

Mapping, Monitoring, Making Decisions

WHRC scientists incorporate satellite and remote sensing technologies with on-the-ground research to map and monitor forests, biomass, habitats, environmental change and ecosystems throughout the globe. Both craft and science, these maps are not only beautiful but they convey a broad range of valuable information as displayed in the following pages. This helps governments, conservation planners, researchers and local communities to make informed decisions.

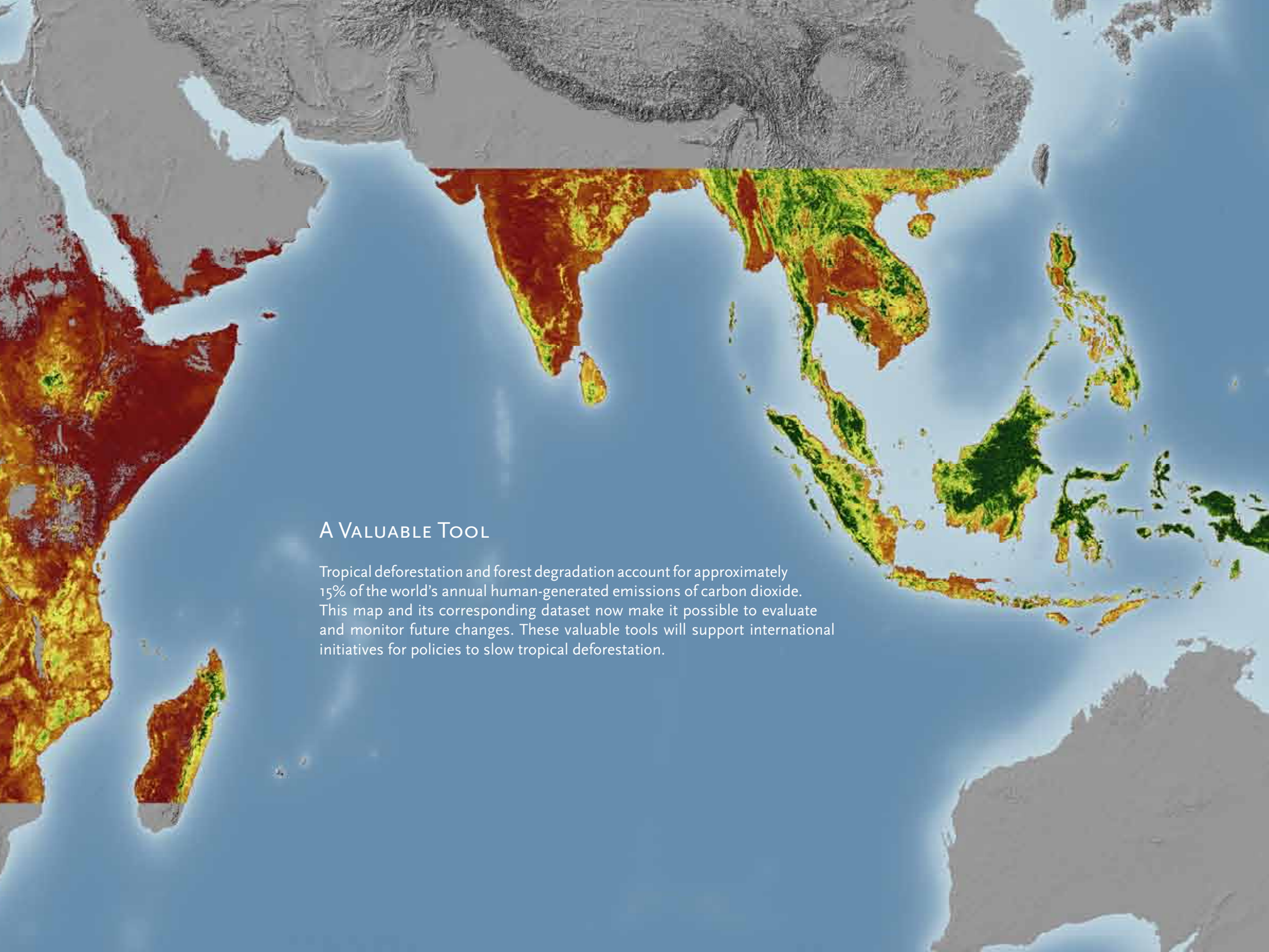
National Biomass and Carbon

WHRC produced this high-resolution "National Biomass and Carbon Dataset for the year 2000," the first ever spatially explicit inventory of its kind. The production of the map and dataset comes at a time when understanding and quantifying the carbon balance for North America is more important than ever. This map of vegetation height, biomass and carbon stock provides a baseline from which to detect future change. The map colors show an increase in aboveground woody biomass values from light to dark green colors with the largest biomass values found in the old growth forests of the Pacific Northwest in red colors.



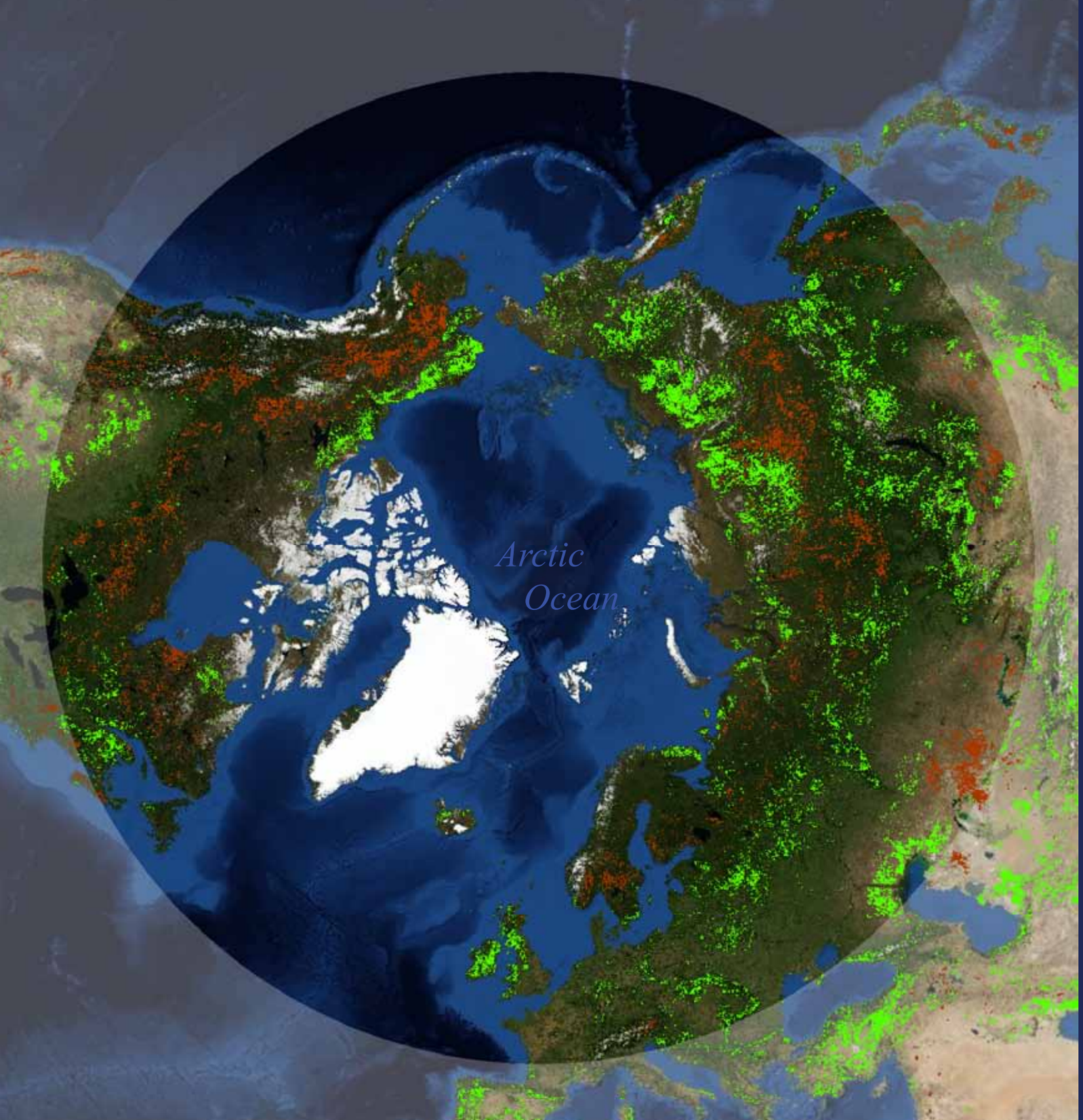
Carbon in Pantropical Forests

As part of ongoing projects in the pantropical region, WHRC scientists and their collaborators generated an aboveground biomass dataset for tropical countries. Using a combination of field measurements and satellite imagery, the researchers produced maps showing the amount and spatial distribution of aboveground carbon. This information makes it possible for tropical countries to accurately report carbon emissions from deforestation and land cover change as part of evolving United Nations negotiations to include tropical forests in emissions reduction strategies.



A Valuable Tool

Tropical deforestation and forest degradation account for approximately 15% of the world's annual human-generated emissions of carbon dioxide. This map and its corresponding dataset now make it possible to evaluate and monitor future changes. These valuable tools will support international initiatives for policies to slow tropical deforestation.



Productivity in the Arctic

Centered on the Arctic Circle, this projection of the Earth shows Greenland in white. The green, orange and brown shading identifies where plants are responding to climate change by growing better (increasing productivity), where they are growing worse (decreasing productivity) and where fire has spread. As shown in the light green, increasing productivity is occurring in the region dominated by tundra, whereas decreasing productivity (mapped as orange) and most of the burning (mapped as brown) are happening within the region of the boreal forest. Warmer temperatures and a longer growing season are allowing tundra grasses, sedges and shrubs to grow better, but summer heat and drought are causing stress to the trees of the boreal forest, leading to tree death, susceptibility to insects and disease and more frequent fire.

Chris Linder

Chris Linder

Aron Stubbins


Toby McGrath

Fishermen on Lago Verde (Green Lake) near Santarém, Pará, Brazil wait for schools of a fish called jaraqui to swim into the lake from the Tapajós River. Thousands of riverine communities conduct small-scale fishing activities on the Amazon and its tributaries. To assess the sustainability of fishing resources in the lower Amazon, WHRC analyzed over 20,000 household fishing activity interviews between 1992 and 2007. The findings were used to inform policy and management. Top photos: WHRC scientists and students on field projects collect samples and track data in Siberia and Alaska.

Education: Learning, Measuring, Teaching

Wading through mud and waving off mosquitoes while clutching gear and sampling water, Woods Hole Research Center scientist Max Holmes leads a group of thirty students through a small patch of Siberian tundra. Taking part in ***The Polaris Project***, the students will learn how to monitor climate change by, among other things, evaluating river water in Russia. It's just one part of our vision for education.

In past years members of the ***Pantropical Scholars*** mapping project visited WHRC from a range of countries including Bolivia, India, Uganda and Vietnam to expand their skills in forest measurement. They came from diverse backgrounds, but all shared the common goal of slowing tropical deforestation.


Chris Linder

Taking part in the Polaris Project, two students collect water samples in Russia's Kolyma River.

As part of the ***Brazil Research Experience***, WHRC sends local Falmouth, Massachusetts High School teachers to a soy ranch in the Brazilian state of Mato Grosso where they learn how to study the transitional forest on the edge of the Amazon rainforest to see how fire, land use change and deforestation affect the vigor of animal habitat. The teachers then share what they learn with their students in Falmouth.

We hope to develop an innovative two-week intensive four-credit summer-term graduate course to equip participants with the tools and techniques needed to measure and monitor forest carbon across large areas of the globe. This ***Boston University Partnership*** would aim to provide an understanding of the ground-based techniques that provide the foundation for a detailed analysis of data from current and near-future satellite and aircraft-based remote sensing.

Our ***Visiting Scholars*** program has welcomed researchers from around the world, including Brazil and the former Soviet Union, since the late 1980s. During a residency at the Center, the scholars work with staff and are encouraged to consider potential future collaborative projects with WHRC scientists.

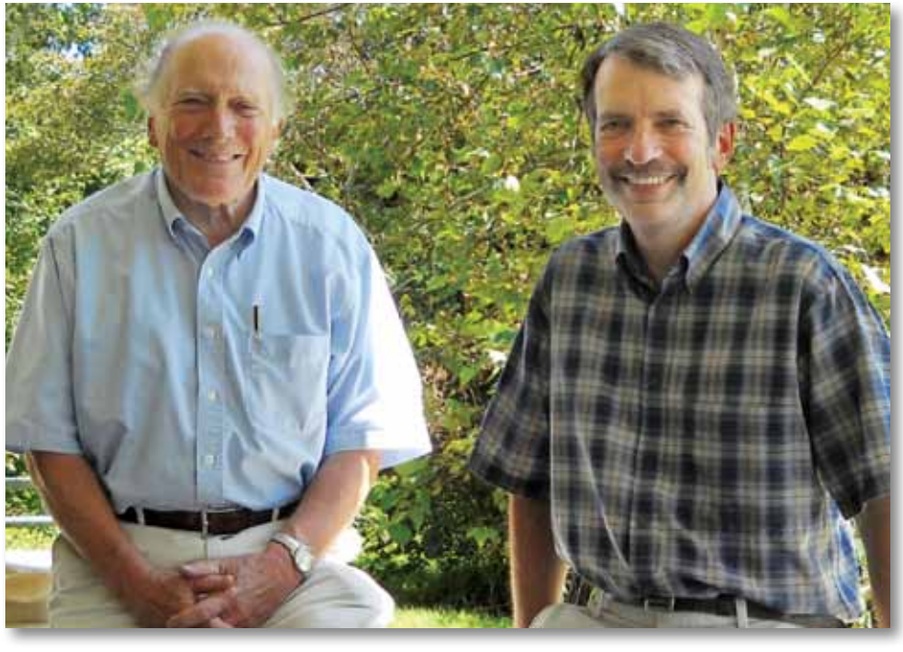
Education is integral to the WHRC mission, incorporating as it does on-the-ground field work and collaborations that improve management of forest resources around the globe. Whether through capacity-building workshops, one of the above programs, or related activities, new findings and maps are being produced, assessed, disseminated and discussed with various stakeholders from government, civil society, indigenous and traditional forest communities and the private sector.

"Much as human health can be evaluated by analyzing blood chemistry, so too can watershed health be assessed by monitoring river water chemistry. We're teaching the next generation of climate change scientists how to do that." Dr. Max Holmes, Senior Scientist

Large tundra wildfires are becoming more prevalent. In the exceptionally dry summer of 2007, lightning caused a fire that started on July 16, burned 256,000 acres and continued until the end of September when nearby lakes had already frozen over. The blaze released as much carbon into the air as the entire Arctic tundra absorbs in a year. Fires in this ecosystem are historically uncommon because the ground was covered in snow and ice for long periods.

Addressing the Great Issues of our Planet

Founded in 1985 by world-renowned ecologist George M. Woodwell, the Woods Hole Research Center is a private, nonprofit research organization focusing on environmental sciences. The Center's 60 staff members are dedicated to help solve the planet's greatest environmental issues, combining analysis of satellite images of the Earth with field studies to measure, model and map changes in the world's ecosystems—from the thawing permafrost in the Arctic to the expanding agricultural regions of the tropics.



George M. Woodwell, Founder, and Eric A. Davidson, President and Senior Scientist.

WHRC, through our science and policy efforts, played an important role in defining and describing the state of the science upon which the United Nations Framework Convention on Climate Change was based in 1992. Since then, however, the contribution of science to the public discourse on climate disruption has been eroding. It is now time for a new set of insights and initiatives to build a universal attitude of enthusiasm, hope, and intellectual and financial support as we address the great environmental issues of our world.

As we look forward, what is needed is a broad societal commitment to restore the relative climatic stability that existed throughout the history of human civilization, that supported biological diversity, and that made agriculture possible. This can be achieved by stabilizing and regaining forest cover, soil fertility and water resources, while enabling sustainable farming, forestry and industry. WHRC is working locally and regionally, with unsurpassed expertise and collaborations in North and South America, Asia and Africa. We also work globally, focusing on how humans are changing the carbon, nitrogen and water cycles. Our education and communication strategies bring forth the urgency of these great issues of our time. Our approach is to merge natural science with economics, discovering and communicating sustainable paths for human prosperity and stewardship of the Earth's natural resources.

Funding for the Center is provided through government grants, corporate and foundation support and individual donors.

How to Get There: Ways to Give

You may never know the full impact of your giving, but future generations will.

Your gift to the Woods Hole Research Center is an investment in our mission to advance scientific discovery and to seek science-based solutions for a sustainable future for our planet.

In addition to support from foundations and government agencies, it is the generosity of individual donors that enables WHRC to understand the impact that humans have on the great natural systems of the world, and to promote the critical role that science plays in providing solutions. With your help we can work to slow climate change, stabilize soils, purify water, and provide wildlife habitat, while sustaining human well-being and prosperity.

Climate change, sustainable land use and water resources are among the great environmental issues we face today, and they will only become more pressing. These are the challenges that will define the next decade, the next generation and the next century. What we choose to do today will be our legacy.

What will your legacy be? Whether you'd like to help an emerging scientist, be a part of efforts to protect the world's forests, support public outreach and education of the next generation of climate scientists, or push discovery of new findings about our dynamic planet to the next level, your donation to the Woods Hole Research Center can make a vital difference to the future of our planet.

Giving Opportunities

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Our Development Office is here to assist you in making your gift as convenient and rewarding as possible. *Naming opportunities are available.*

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A view of the Iberian Sea from the International Space Station. WHRC studies of the Earth's ecosystems rely on data collected both from satellites in space and scientists on the ground far below. Photo courtesy NASA.

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