

CARNEGIE  
INSTITUTION FOR  
SCIENCE

# GLOBAL ECOLOGY

Scientific Foundations for a Sustainable Future



# New Directions

global agriculture | coastal oceans





# What is Global Ecology?



Understanding the function of our planet as a complex, integrated system is one of the great challenges of our era.

**Global Ecology is the study of the global environment—the earth’s ecosystems, its land, its atmosphere, its oceans, and how all those parts interact. The global environment is almost unbelievably complex, with countless organisms and diverse processes interacting over scales from the microscopic to the continental. But we increasingly have the instruments, models, and theories to ask and answer fundamental questions**

**about the way the system works. In coming decades, some of the most important breakthroughs in science will be in global ecology.**

As our world grows ever smaller, we cannot ignore the fact that our global environment is changing

**Because we humans have unprecedented power to change the planet, it is essential that we understand how the planet works and how human actions alter it—both nearby and distant, both short-term and long-term.**

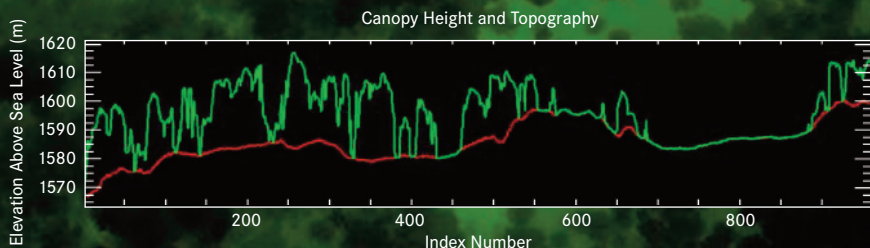
**The goal of the Department of Global Ecology is to understand how natural processes and human actions work together to shape the behavior of the earth.**

**This understanding is fundamental, but it is more than that. It gives us the foundation to be more effective stewards of our planet.**



# Our Commitment

The Carnegie Airborne Observatory (directed by Greg Asner) maps the three-dimensional structure of vegetation in forests and other natural areas. This image, from a tropical woodland in Hawaii, shows the location and shape of each tree. The inset image provides a cross-sectional view of the terrain (red line) and tree canopies (green line).



## Since its opening in 2002,

the Carnegie Institution's Department of Global Ecology has been exceptionally productive—in science, environmental policy, and raising public awareness of climate change. In just six years, the department's scientists have published more than 150 papers, including many in the most prestigious peer-reviewed journals. Research at the department has attracted support from some of the most discriminating foundations in the country, including Keck, MacArthur, Mellon, Moore, and Packard. It is now time to build on that record of achievement and take the Department of Global Ecology to scale in order to achieve its full potential in understanding the underlying mechanisms of ecological processes and its contribution to meeting some of the greatest challenges facing humankind.

### Michael Gellert

*Chairman*  
Board of Trustees  
Carnegie Institution of Washington

## The coming decades

will present humankind with challenges, in particular those resulting from growing concentrations of greenhouse gases. The world that we bequeath to our children and grandchildren will inevitably be far different and in many ways far less pleasant than the one we inherited. It is crucially important that we develop a deep understanding of the global mechanisms that will drive these changes now so we can motivate timely action and our strategies for prevention and mitigation will be sound and effective. I see the expansion of research such as that undertaken by Carnegie's Department of Global Ecology as an imperative for humankind's future.

### Richard A. Meserve

*President*  
Carnegie Institution of Washington

## We live in a world

of tremendous complexity and momentous challenges. Some of the most important challenges involve the sustainability of the natural world: climate change, biological diversity, agricultural productivity, and the health of the world's oceans. But we also live in an era of prodigious increases in scientific knowledge, and we have the potential to make real progress on questions that have long been considered outside the reach of even the best science. Carnegie's Department of Global Ecology is uniquely positioned to capitalize on the excitement while making real contributions that help lay the foundations for a sustainable future.

### Christopher Field

*Director*  
Department of Global Ecology

Christopher Field (above) contributed to the Intergovernmental Panel on Climate Change that received the 2007 Nobel Prize. He was one of two US scientists selected to attend the Nobel ceremony in Oslo.



# A Powerful Department

Selected examples of the role of Global Ecology faculty in bringing science issues to the public and policy arenas:

2007

- **Field** is a coordinating lead author on report from IPCC group that shared the 2007 Nobel Peace Prize
- **Field** briefs US Senate Environment and Public Works Committee on climate change impacts
- **Caldeira** op-ed on forests and climate change in *The New York Times*
- **Asner** named to *Popular Science* Brilliant 10, the magazine's selection of the country's 10 most exciting young scientists
- **Field**'s work on CO<sub>2</sub> emissions runs as headline story in *USA Today*
- **Field** briefs Western Governors Conference and western state legislators on climate change impacts
- **Caldeira** presents a series of business commentaries and participates in debate on geoengineering on BBC World Service

2006

- **Caldeira** featured in *The Darkening Sea*, published in *The New Yorker*
- **Asner** briefs Brazilian government on quantifying illegal logging
- **Asner** briefs U.N. delegates to the Kyoto Protocol on deforestation monitoring
- **Field** featured in documentary, *The Great Warming*
- **Caldeira** features in *LA Times* series on Altered Oceans

2005

- **Asner**'s *Science* paper on cryptic deforestation covered in hundreds of newspapers
- **Field** briefs US House Science Committee on climate change impacts

In 2007, The American Institute of Architects named the Global Ecology building among the top 10 examples of sustainable architecture and green design solutions.

## Pursuing a rich tradition

The unique "Carnegie Model" is recognized worldwide because of its:

- consistent record of major breakthroughs
- dedication to scientific research, investigation, and discovery
- investment in exceptional individuals
- provision of stable support for research
- cultivation of a culture of successful collaboration

## Advancing the new field of Global Ecology

Although the origins of ecology go back more than 200 years, the 21st century brings with it an understanding that the whole earth is, for many purposes, a single complex ecosystem. Carnegie's Department of Global Ecology pursues the measurement, analysis, modeling, and ultimately understanding of this most complex system.

## A scientific powerhouse

Since its formation in 2002, the department has emerged as a broadly recognized international leader in global ecology. Its work appears in the most prestigious scientific journals, and its scientists have leadership positions in major international programs.

## A department in the public eye

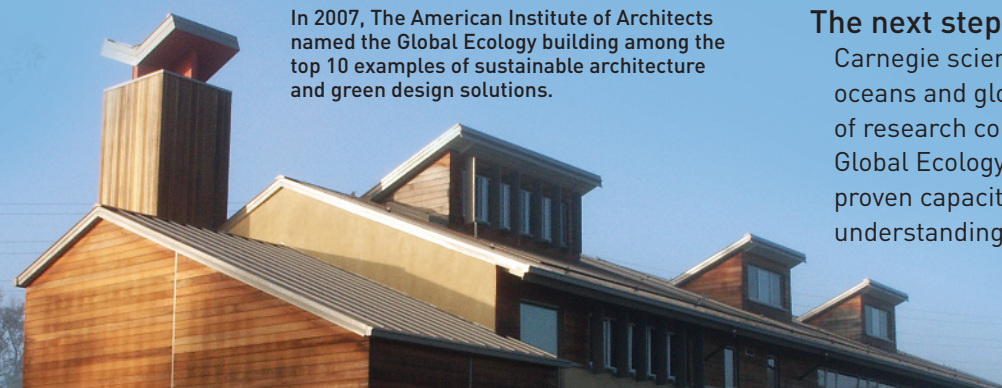
Work of Carnegie scientists on climate change, alternative energy sources, remote sensing, and other topics has been covered by major news stories in newspapers, magazines, radio, and television. Carnegie scientists are leaders in many high-profile projects, including the Nobel Prize-winning work of the Intergovernmental Panel on Climate Change.

## Looking ahead

Although Global Ecology already has made paradigm-shifting contributions to the understanding of complex environmental problems, it has not yet reached the critical mass necessary to tackle many of the most difficult and important scientific challenges. Now is the time to take the department to scale, to apply its capabilities to understanding the scientific foundations of critical environmental issues, and to maximize its impact on science and society.

## The next steps

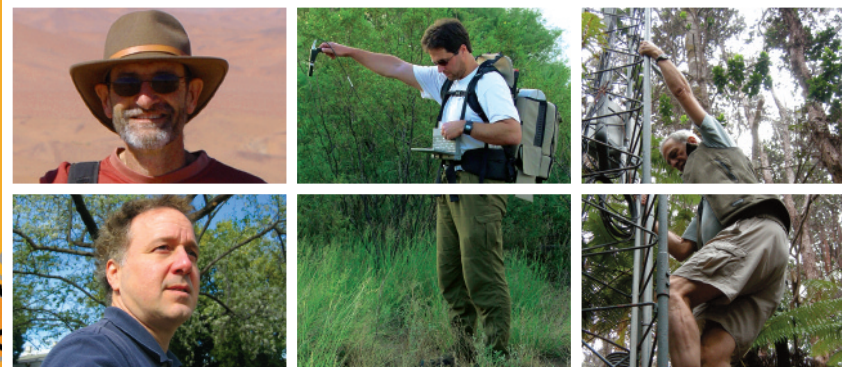
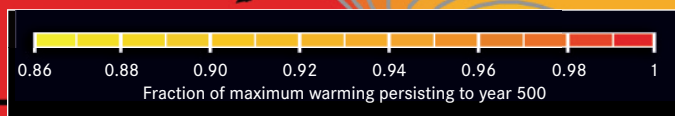
Carnegie scientists have identified two areas—coastal oceans and global agriculture—in which the Carnegie style of research could make transformational discoveries. The Global Ecology Initiative seeks \$35 million to build on the proven capacity of the department to provide scientific understanding of emerging environmental concerns.









# Understanding Climate Change

Carnegie scientist Ken Caldeira and former postdoc Damon Matthews have calculated that when new carbon dioxide is added to the atmosphere, more than 95% of its global warming effect is still present after 500 years. Information such as this is essential for anticipating the effects of future carbon dioxide releases to the atmosphere.



**The Department of Global Ecology** is deeply involved in efforts to understand the productive capacity of the earth's ecosystems and how this capacity is changing in response to climate change. Department scientists investigate the distance scale from the very local to the global and the time scale from past centuries to the end of the current century and beyond; they are leaders in this evolving field.

-  **Chris Field** leads ambitious efforts to measure the responses of terrestrial ecosystems to climate change. He was one of the first to use satellite data to quantify plant growth. His work has shown that global warming has already had a negative impact on agricultural productivity, reducing yields of corn, wheat, and barley; those losses currently exceed \$5 billion per year.
-  **Greg Asner** has developed improved techniques for extracting fine-resolution information from LANDSAT satellite data. His analysis of rainforest disturbance in the Brazilian Amazon identified much larger logging areas than had previously been known. Recently, he has developed a new generation of Carnegie owned and operated aircraft-based remote sensing systems that provide spatial resolution of one square foot or better, thus affording unparalleled access to localized effects of climate change and ecosystem disturbance.
-  **Ken Caldeira** has been a leader in projecting how carbon dioxide emissions will change the world's climate over the next century. His studies of light and greenhouse gas effects demonstrate that planting forests does not always lead to a net cooling, especially in regions with snowy winters. His studies of coral reefs are a sober reminder of anticipated loss of coral throughout the world's oceans. He is a leader in efforts to analyze and understand the implications of proposals to protect the earth's climate through mechanisms like changing the reflectivity of the earth.
-  **Joe Berry** has led efforts to obtain a more complete picture of our atmosphere and how it is changing. He has developed a powerful new technique for measuring local and regional exchanges of carbon, over spatial scales up to thousands of square miles. This technique allows use of local information at the plant scale to understand carbon balance at regional to continental scales.

# Adding Breadth Two New Focus Areas



## Coastal Oceans

More than half the world's people live within 30 miles of a coast. No part of the earth system operates in isolation, but interactions are nowhere more important (and more complex) than in this coastal zone.

Coastal oceans are dramatically different from the open ocean, and as a result, they are poorly understood. Recent advances in remote sensing and fluid dynamics promise new insights into the coastal oceans in areas such as fisheries management, carbon sequestration, toxic algal blooms, and coral reef bleaching. Important progress is also likely to come from linkages among areas, such as currents, nutrients in the water column, dispersal of fish and invertebrate larvae, photosynthesis, human health, and sustainability.

A coastal oceans research group in the Department of Global Ecology will combine physical and biogeochemical perspectives with organismic and ecological perspectives. Their work will enhance and benefit from interactions with experts in land as well as open ocean processes. This interdisciplinary approach is in the best tradition of Carnegie science.

## Global Agriculture

A growing human population, climate change, and increasing demand for meat-based diets and biofuels combine to create a series of difficult challenges for agriculture. Increasingly, these challenges to agriculture interact with the need to understand and protect the global environment.

Continuing to maintain progress in increasing yields of food plants will require improvements in cultivars and agricultural chemicals, but it will also require a thorough understanding of the opportunities and constraints from local climate, soils, micro-organisms, weeds, insects pests, and risks of extreme events. Other challenges include more accurate yield projections, possible feedbacks of croplands to the global climate, and the need to develop new varieties to cope with climate variability. A success in securing the integrity of the global food system will require linking many specialties, including crop breeding, climatology, hydrology, biogeochemistry, plant pathology, plant-insect interactions, plant physiology, and agronomy.

A Global Ecology laboratory team focused on global agriculture can make unique contributions to food security. In the Carnegie traditions, this team will be strongly symbiotic with existing expertise in the Department of Global Ecology—in areas such as global plant growth, deforestation, biological invasions, land surface feedbacks to climate, and terrestrial carbon and nutrient cycles.



# Making it Happen

The proposed expansion will require additional annual expenditures, growing from \$300,000 in 2008 to \$2.0 million in 2010, with a steady-state need for an additional \$1.5 million per year, in 2012 dollars. This represents an approximate doubling of the Carnegie Institution's endowment support for the Department of Global Ecology in 2007-2008. Carnegie also must raise current-use funds for immediate expansion at the same time that it seeks endowment funding for a permanent base of support. Start-up funds will allow immediate hiring and expenditures during the period when endowment funds are being sought and invested.

To support the Global Ecology Initiative, the Carnegie Institution for Science seeks \$35 million. This overall goal includes \$10 million in expendable support over five years for new positions, instrumentation, program support, and operating needs plus \$25 million in endowment to provide permanent support for positions, instrumentation and facilities, and continuous operational support. These goals are summarized below.

## EXPENDABLE FUNDS (over five years)

Start-up funds for Carnegie Investigators, staff associates, post-doctoral fellows, instrumentation, and lab development	\$ 5,000,000
Support for specific research programs and projects	\$ 5,000,000
<b>Total expendable support</b>	<b>\$10,000,000</b>

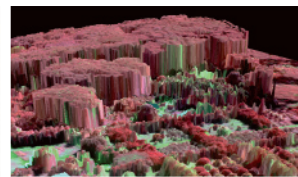
## ENDOWMENT FUNDS

<b>Two additional Carnegie Investigators</b> , leading scientists of outstanding breadth and creativity, who will, in collaboration with Carnegie and non-Carnegie researchers, develop research programs that build the scientific foundations for addressing coastal oceans and global agriculture.	\$ 8,000,000
<b>Two Carnegie Staff Associates</b> : accomplished young scientists in five-year appointments with great independence.	\$ 4,000,000
<b>Four post-doctoral fellows and/or graduate students</b> who play a critical role by contributing to research breakthroughs, by forging links among labs, and by conveying Carnegie research techniques to other institutions.	\$ 6,000,000
<b>Operating funds</b> which cover technical and administrative staff, purchasing of new equipment, and research activities.	\$ 7,000,000
<b>Total endowment</b>	<b>\$ 25,000,000</b>
<b>TOTAL NEEDED</b>	<b>\$ 35,000,000</b>



## SCIENCE FOR SUSTAINABILITY

- The uniquely successful Carnegie tradition of collaborative research
- Tackling some of the grand challenges in modern science
- Opportunities for fundamental breakthroughs
- Immediate application to solving real-world problems



Andrew Carnegie founded the Carnegie Institution of Washington in 1902 as an organization for scientific discovery. His intention was for the institution to be home to exceptional individuals—men and women with imagination and extraordinary dedication capable of working at the cutting edge of their fields. Working in six scientific departments on the West and East Coasts, Carnegie investigators are leaders in the fields of plant biology, developmental biology, earth and planetary sciences, astronomy, and global ecology. They seek answers to questions about the structure of the universe, the formation of our solar system and other planetary systems, the behavior and transformation of matter when subjected to extreme conditions, the origin of life, the function of genes, and the development of organisms from single-cell egg to adult, and help build the scientific foundations for a sustainable future through basic research of large-scale environmental issues, including climate change, ocean acidification, biological invasions, and changes in biodiversity.

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