
THE FULL PICTURE
GEO
GROUP ON
EARTH OBSERVATIONS

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Australian Greenhouse Office
www.greenhouse.gov.au

British National Space Centre
www.bnsc.gov.uk

Bureau of Meteorology, Australia
www.bom.gov.au

Department of Science and Technology, Republic of South Africa
www.dst.gov.za

Earth Remote Sensing Data Analysis Center, Japan
www.ersdac.or.jp/eng/index.E.html

European Centre for Medium-Range Weather Forecasts
www.ecmwf.int

European Space Agency
www.esa.int

Geo-Informatics and Space Technology Development Agency, Thailand
www.gistda.or.th

Global Observation for Forest and Land Cover Dynamics
www.gofc-gold.uni-jena.de/sites/geo.php

Indian National Center for Ocean Information Services
www.incois.gov.in

Infoterra France
www.infoterra.fr

Instituto Nacional de Meteorologia, Spain
www.inm.es

Japan Aerospace Exploration Agency
www.jaxa.jp/index_e.html

Korea Meteorological Administration
www.kma.go.kr/intro.html

National Oceanic and Atmospheric Administration, U.S.A.
www.noaa.gov

National Physical Laboratory, India
www.nplindia.org

The South African Environmental Observation Network
www.saeon.ac.za

South African Weather Service
www.weathersa.co.za

U.S. Geological Survey
www.usgs.gov

Wageningen University & Research Centre, Centre for Geo-Information, Netherlands
www.grs.wur.nl

Yonsei University, Dept. of Atmospheric Sciences
http://koflux.yonsei.ac.kr

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Smithsonian Institution Global Earth Observatories

Ira Rubinoff, Smithsonian Institution, Office of the Undersecretary for Science;
Eldredge Bermingham and Charles Lydeard, Smithsonian Tropical Research Institute;
Stuart J. Davies, Smithsonian Tropical Research Institute and Arnold Arboretum, Harvard University

The Smithsonian Tropical Research Institute (STRI) is a US organization dedicated to advancing fundamental scientific discovery and understanding of biological diversity in the tropics and its contribution to human welfare. STRI plays a critical role for the US Government and the Smithsonian by maintaining world-class research facilities in Panama. Last year more than 1,000 resident and visiting scientists accessed diverse tropical environments, including rain forest and coral reef ecosystems at the facility. STRI serves as official custodian for the Barro Colorado Nature Monument (BCNM) in Panama under the terms of the Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere, which was ratified by the US Senate in April 1941. The BCNM is the only mainland tropical reserve under US stewardship.

More than 25 years ago STRI established a large-scale forest research plot on 50 hectares (approximately 120 acres) of lowland tropical forest on Barro Colorado Island (BCI), a fully protected tropical forest within the BCNM. Within the plot, every free-standing tree with a diameter at breast height of at least one centimetre was tagged, measured, mapped and identified to species. Beginning in 1980 the plot has been censused every five years, with the sixth census completed in 2006.

Over the years, re-censuses have revealed that tropical forest populations are incredibly dynamic and responsive to climate change. For example, in only one census interval of five years, more than 40 per cent of the tree species in the plot changed by more than ten per cent in total abundance. This was apparently in response to a severe El Niño drought that elevated death rates up to 20 times those of non-drought years. The large-scale and standard forest census methods developed on BCI proved to be a powerful approach to studying the dynamics of tropical forests. By 1990, scientists around the world had replicated the STRI methods, and a global network of research plots emerged.

The network was initially named the Center for Tropical Forest Science (CTFS), and although administered by STRI, individual forest plots are led and managed in each country by one or more partner institutions (see Appendix). For example, the Indian Institute of Science manages the forest dynamics plot in Mudumalai, India, and the National Institute of Research of the Amazônia is the custodian of the CTFS plot in the Central Amazon. In addition, CTFS in Asia is coordinated through a partnership with the Arnold Arboretum of Harvard University.

CTFS coordinates research activities using standardized methods on forest plots ranging from 2 — 52 hectares that now include 20 sites in 15 tropical countries in Latin America, Africa and Asia. The CTFS plots involve hundreds of scientists from more than two dozen institutions. Over the past 25 years, the CTFS network has created the first actuarial table for tropical trees around the world, thus providing a basis for determining quantitatively how trees and forest ecosystems are responding to the Earth's changing climate. This international collaboration is now monitoring the growth and survival of 3.5 million trees in over 6,500 species, which constitutes over 12 per cent of all known tropical tree species. The CTFS system has now matured to the point where there is a tremendous and unique opportunity to expand the programme into a truly interdisciplinary research endeavour that will enable the world's scientists to investigate key indicators of global environmental health.

STRI is now in the process of transforming its network of tropical forest plots into the Smithsonian Institution Global Earth Observatories (SIGEO). Although tremendous advances in our understanding of tropical diversity and dynamics have been gained from 25 years of research across the network of tropical forest plots, CTFS and its system of global earth observatories is poised to make an even larger contribution through monitoring the effects of anthropogenic increases in atmospheric CO_2, nitrogen and general air pollution at local, regional and global scales.

The global earth observatories will provide baseline data to help solve real-world problems through real-time dissemination of critical data and cutting-edge science. It is worth noting that the network is extremely well utilized by independent university-associated faculty and network partners, thus SIGEO leverages huge intellectual horsepower. Over 200 scientists have published over 1,000 scientific articles from the CTFS data sets, attesting to the broad usability and benefits of the network.

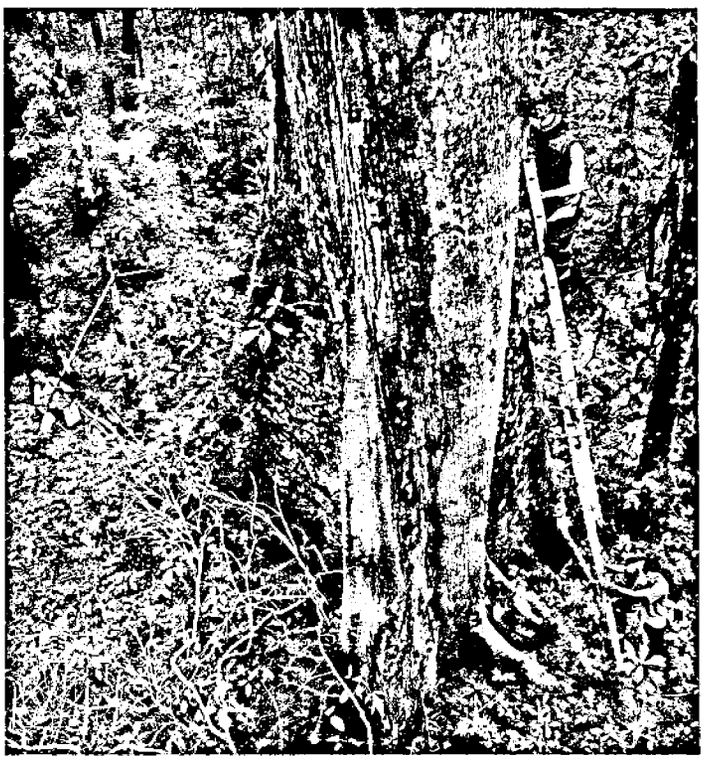


Photo: Marcos A. Guerra

Researchers measuring trees at Barro Colorado Island, Panama

The Smithsonian Institution is uniquely positioned to conduct interdisciplinary research on complex biological systems at a global scale. It will do this by expanding and deepening its collaborative ventures among units including the National Zoological Park's (NZP) Conservation and Research Center (CRC), the National Air and Space Museum (NASM), the National Museum of Natural History (NMNH), the Smithsonian Astrophysical Observatory (SAO), the Smithsonian Environmental Research Center (SERC) and STRI.

SIGEO will contribute to fulfilling the strategic plan of the US Climate Change Science Program (CCSP) and addressing a proposed CCSP priority of reducing scientific uncertainty about potential effects of climatic change on ecosystems. Furthermore, the Intergovernmental Panel on Climate Change (IPCC) Working Group II assessment report has shown the great need for better observational data on climate change impacts, and has particularly pointed out the need for systematic and comprehensive observations that SIGEO will provide.

Finally, the Smithsonian is reaching out to build or strengthen collaborations with government agencies of the United States including the US Environmental Protection Agency (US EPA), US Geological Survey (USGS), US Department of Agriculture (USDA) Forest Service, National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautics and Space Administration (NASA). Such efforts are focused particularly on the intergovernmental Group on Earth Observations (GEO) and the implementation of the Global Earth Observation System of Systems (GEOSS). The Smithsonian Institution is interested in expanding the opportunities for collaboration and partnerships among agencies to maximize the increase and diffusion of knowledge.

The Smithsonian will transform the CTFS network of tropical forest plots into a system of SIGEO in three primary ways.

Global carbon research programme

Human activities have caused a 15 per cent increase in atmospheric carbon dioxide in the past 40 years and are set to increase atmospheric CO_2 levels even more dramatically in the coming decades. This increase, coupled with equally dramatic increases in other greenhouse gases, is having a profound effect on global climate, and on terrestrial and oceanic ecosystems. Regrettably, there is a tremendous gap in our understanding of the role of forests in the global carbon budget, and insufficient evidence on whether temperate and tropical forests behave differently under changing global conditions.

SIGEO plots provide in situ measures of above- and below-ground carbon and how it is changing in response to rising CO_2. A recent publication by CTFS scientists using data from two forest plots with measurements for over 20 years (BCI, Panama and Pasoh, Malaysia) has shown that despite increased carbon fertilization, growth rates of tropical forest trees has decreased. This decrease is perhaps a response to global warming. Rigorously generated, long-term data from a global network of plots will provide critical empirical data for modelling carbon dynamics in the future. It will also provide direct measurement of whether efforts to reduce carbon emissions are effective.

Branching out into the temperate zone

Because of differences in seasonality, albedo and other climate factors, tropical and temperate forests are anticipated to behave differently with regard to changes in atmospheric carbon dioxide levels and changing temperatures. Currently no temperate-zone plots follow the same methodology as the tropical plots but the SIGEO initiative will take advantage of long-term forest plot-associated research at the CRC of the Smithsonian NZP and the SERC to quickly establish a series of large-scale temperate plots that will permit direct comparison to the tropical plot network.

Partnerships in temperate China and Europe are being developed to help expand these temperate-tropical comparisons to a global scale. HSBC has recently formed a partnership with the Smithsonian Institution and the Earthwatch Institute to establish a regional training centre on climate change at SERC.

Scientists at SERC and CRC have a rich and productive history of conducting long-term environmental studies such as measuring the effects of atmospheric CO_2 on plant and soil microbial communities, biodiversity monitoring and assessment, landscape ecology, and the biology of migratory birds.

Expanding the monitoring programme: looking beyond the trees

Scientists from CRC, the NMNH, and STRI will significantly improve assessment of the impact of global change on biodiversity through focused surveys of vertebrates, invertebrates and microbes across the global earth observatories. Standard methods for measuring and

monitoring biodiversity of different groups of organisms will be developed and distributed.

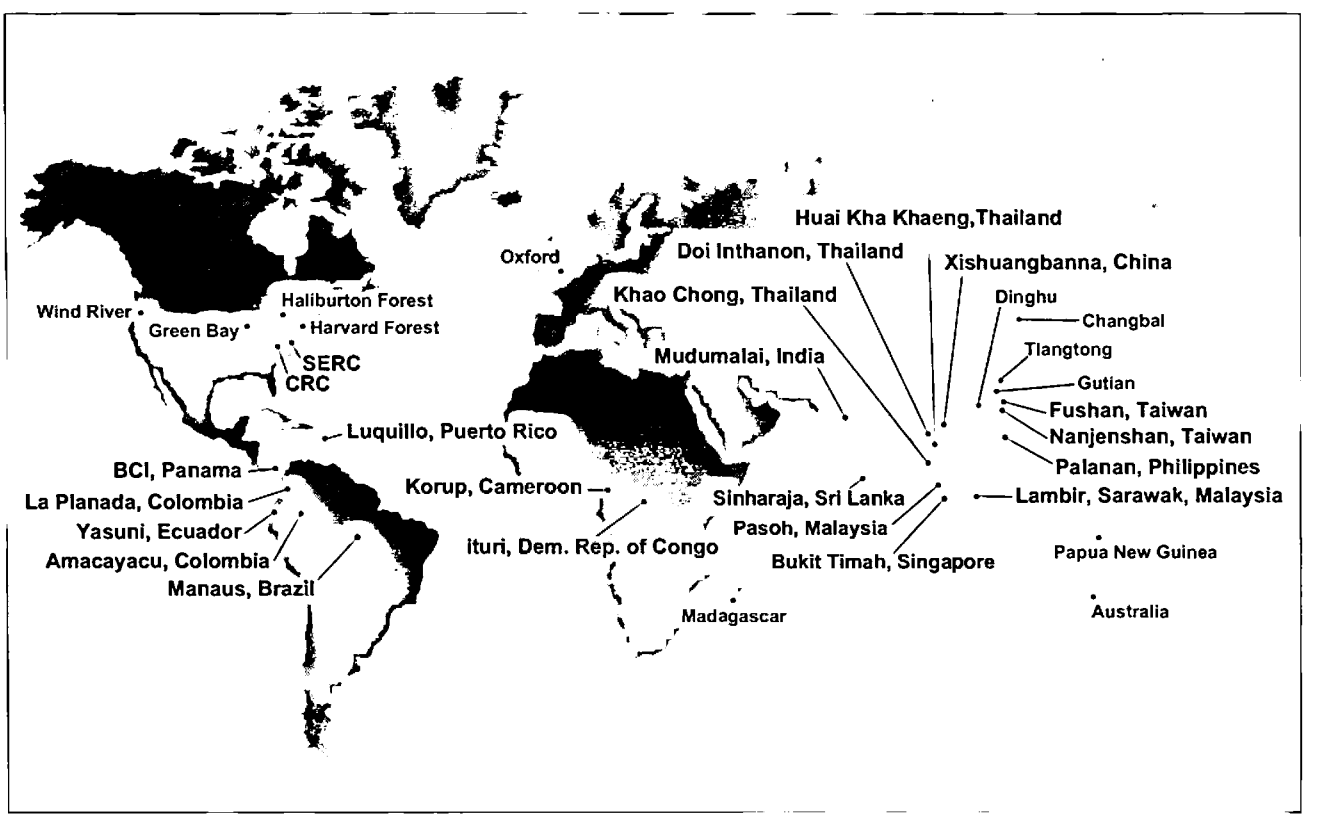
The use of identical sampling methods has been a central tenet of the CTFS programme and allows for maximal combinability and comparability of the data. In addition, this research will be coupled with training workshops to build professional capacity in developing countries to maintain biodiversity monitoring programmes. It is hoped that this, in turn, will lead towards wise decision-making for sustainable management of natural resources. The Monitoring and Assessment of Biodiversity (MAB) Program at CRC and STRI have considerable experience in fostering the growth of professional capacity.

Furthermore, NMNH scientists will work with STRI scientists to DNA barcode selected taxonomic groups such as trees, invertebrates, nematodes and microbes. The Smithsonian Institution is the host of the Consortium for the Barcode of Life, an international initiative devoted to developing DNA barcoding as a global standard in taxonomy. Many if not most of the plants, invertebrates, nematodes and microbes in the tropics are formally undescribed species, including some of the tree species that have been mapped and measured on the plots. Coupling the formal taxonomy with DNA barcoding will provide an extremely useful database for future researchers interested in genetics, systematics, and bioprospecting.

Finally, scientists from the NASM and the Smithsonian Astrophysical Observatory (SAO) will work to link data on the ground (plots) to regional and global predictions through space-based assessments. For example, SAO has pioneered the measurement of formaldehyde (HCHO) from space, its use as the main proxy for volatile organic compound (VOC) emissions, and the development of a climatology of emissions. Isoprene is emitted by heat-stressed trees and is thus a direct indicator of global heat stress on forests. NASM in turn, will use remote sensing technology to extend ground-based measurements of carbon dynamics to broader scales.

CTFS has successfully melded observation, data analysis, models, and basic and social research to enable scientists and policymakers to better understand global environmental issues. The expanded methodology and objectives of SIGEO will provide the necessary platform to supply critical scientific data to address the needs of society into the future. In the environmental sciences, CTFS stands as one of the premier international partnerships, and SIGEO aims to integrate the SI network of forest dynamics plots with the GEOSS to further advance the progress of science across borders. CTFS and SIGEO promote large-scale environmental monitoring, and maintain enormous banks of data and metadata that galvanize advanced data networks and sophisticated analyses from forest plots to outer space.

SIGEO sites



Twenty-two established SIGEO sites in black (blue dots) and 12 candidate sites in blue (red dots). CRC and SERC are also shown

Source: Lina Gonzalez, Smithsonian Tropical Research Institute (STRI)

Notes & References

The following are notes and bibliographical references to the articles contained within *The Full Picture*, as provided by the individual authors. For further information on any article or author, please contact the publisher.

I
National and Regional Reports

GMES and GEOSS: towards a new era in Earth observation

1. Council of the European Union, 4th Space Council Resolution on the European Space Policy, 2007

Earth observations - JAXA's role

Japan Aerospace Exploration Agency

1. See NOAA's Role in Space-Based Global Precipitation Estimation and Application, National Academy of Sciences, August 2006

The INM's Izaña Atmospheric Research Centre, a GEO-oriented experience

The Izaña Atmospheric Research Centre (Izaña-ARC) is managed by the Instituto National de Meteorología (INM; the National Meteorological Institute of Spain). The Izaña-ARC has operated a super-site (28°N, 16°W, 2400 m a.s.l.) since 1984 where atmospheric monitoring, research is carried out, and where GEO-oriented multidisciplinary projects, with scope over large regions of the Earth, are developed.

1. www.rbcc-e.org
2. CNRS/Lille University, France; www.loa.univ-lille1.fr/photons
3. http://aeronet.gsfc.nasa.gov
4. www.bsc.es/projects/earthscience/dream
5. Data is available at www.polarvortex.org

The UK piece of the GEO puzzle

1. Further information with links to BNSC partners' websites can be found at: http://www.bnsc.gov.uk

II
The Global Earth Observation System of Systems Components

Observing systems

The blue planet — observations of the global ocean

1. The GOOS writing team is: Keith Alverson, Pierre Bahurel, Peter Dexter, Paul DiGiacomo, Jean-Louis Fellous, John Field, John Gould, Richard Graham, Ed Harrison, Tom Malone, Jose Muelbert, Bob Weller and Stan Wilson.

Why the world needs a global ocean observing system

1. *International Herald Tribune*, 2 August 2007
2. Associated Press, 4 August 2007
3. *International Herald Tribune*, 9 August 2007
4. *International Herald Tribune*, 7 August 2007
5. Associated Press, 9 August 2007
6. Pacific Tsunami Warning Center Bulletin, 8 August 2007
7. Australian Government, Bureau of Meteorology, 3 August 2007
8. *International Herald Tribune*, 12 August 2007
9. Alverson, K. and D.J. Baker, 'Taking the Pulse of the Oceans', *Science* 314:5806, 1657, 2006.
10. Alverson, K. and D.J. Baker, ibid.

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Alverson, K. 'Watching over the world's oceans', Nature 434, 19-20, 2005.

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1. http://wdc.nbii.gov/portal/server.pt
2. http://rockyitscr.usgs.gov/gitan/
3. http://terralook.cr.usgs.gov/
4. http://www.cbd.int/2010-target/default.shtml

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2. Condit 1998, *Tropical Forest Census Plots: Methods and Results from Barro Colorado Island, Panama and a Comparison with Other Plots*. Springer-Verlag Berlin

Appendix 1. CTFS Network Partners

The Americas

Brazil – National Institute of Research of the Amazônia (INPA), Universidade de Sao Paulo; Louisiana State University (USA).

Colombia – Instituto Humboldt, Instituto Amazonico De Investigaciones Cientificas (SINCHI), University of Medellin (UNALMED).

Ecuador – Universidad Catolica de Ecuador, University of Aarhus (Denmark), Chicago Field Museum (USA).

Panama – STRI (USA), Canal Authority (Panama), University of Georgia (USA).

Puerto Rico – University of Puerto Rico, USDA Forest Service.

Africa

Cameroon – Bioresources Development and Conservation Program, Oregon State University (USA), University of Buea (Cameroon).

Democratic Republic of Congo – Centre de Formation et de Recherche en Conservation Forestière (CEFRECOF), Wildlife Conservation Society.

Asia

China – Chinese Academy of Sciences, Xishuangbanna Tropical Botanical Garden.

India – Indian Institute of Science.

Malaysia – Forest Research Institute of Malaysia, Sarawak Forest Department, Osaka City University (Japan), Kyoto University (Japan), National Institute of Environmental Studies (Japan), Harvard University (USA).

Philippines – University of Philippines, Diliman Campus, Manila, (Philippines), Isabela State University, Plan International, Conservation International (Philippines), Harvard University (USA).

Singapore – National Institute for Education at Nanyang Technological University, Singapore National Parks Board, National University Singapore.

Sri Lanka – University of Peradeniya, Sri Lanka Forest Department, University of Sri Jayawardenepura.

Taiwan – Tunghai University, Taiwan Forestry Research Institute.

Thailand – Royal Forest Department, National Institute of Environmental Studies (Japan), Harvard University (USA), National Parks and Wildlife Department, Kyoto University (Japan).

European geological surveys and GEOSS — observing the Earth beneath our feet: why does it matter?

1. Full information on GeoSciML and access to the operational test bed is available at https://www.seegrid.csiro.au/twiki/bin/view/CGIModel/GeoSciML
2. A Directive is a law applicable in all EU member states, to which national laws must conform after a transition period of two years in the case of INSPIRE.
3. The International Year of the Planet Earth and One Geology websites are respectively available via these links: http://www.esfs.org/ (IYPE) and http://www.onegeology.org/ (OneGeology).
4. The European Geochemical Atlas and its underpinning data are freely downloadable here: http://www.gtk.fi/publ/foregsatlas/index.php
5. The list is available for download here: http://www.eurogeosurveys.org/_STUDIOEMMA_WWW/uploads/File/EGS%20Research%20database%2020.06.07.xls

NSF's observing systems: platforms for large-scale environmental research

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Observing systems for the Pacific Islands region — unique challenges for a unique environment

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2. IPCC (2007). *Climate change 2007: impacts, adaptation and vulnerability, a summary for policymakers*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Edited by S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor and H.L. Miller. Cambridge University Press, Cambridge, UK, and New York, USA.
3. Scott, D. Overmars, M., Falkland, T. and Carpenter, C. (2002). *Pacific dialogue on water and climate: synthesis report*. SOPAC, Suva.

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Jung, H. –S., G. –H. Lim, and J. –H. Oh, 2001: 'Interpretation of the transient variations in the time series of precipitation amounts in Seoul, Korea. Part 1: Diurnal variation.' Journal of Climate, 14, 2989-3004.

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GEOSS architecture principles and the GEOSS Clearinghouse

1. Quote attributed to Michael Tiemann, CTO of Red Hat, Inc.

Dissemination/Information systems

The GEOPortal – gateway to GEOSS

1. www.disasterscharter.org