Report of the First GEO Forest Monitoring Symposium

4-7 November 2008, Foz do Iguaçu, Brazil

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GROUP ON EARTH OBSERVATIONS

Executive Summary

The current lack of globally consistent map products for forests is significantly limiting efforts to understand trends in the world's forests. Filling this gap and advancing our knowledge of the status of and trends in the world's forest resources and their long-term ability to support multiple societal benefit areas will require the coordinated development of Earth observation systems. The resulting improvement in forest observations would support the implementation of international agreements. It would also provide a scientific basis for emerging partnerships amongst non-governmental organizations and local communities.

The GEO Forest Monitoring Symposium was convened with the goals of linking existing and planned forest observation systems around the world, identifying new systems where gaps currently exist, and improving access to, and use of, in situ, aerial and satellite Earth observations.

The Symposium concluded that several existing products clearly demonstrate the ability of Earth observations to improve global forest monitoring. However, creating sustained operational systems based on these capabilities will require considerable additional efforts and major investments in capabilities and capacity. These improvements in forest monitoring will be more widely realized with the adoption of stronger open-data policies. The collection of radar data in specified areas with high cloud frequencies to compliment optical data is specifically important. For many developing countries, significantly increased efforts in capacity building are needed to derive the full benefits of the data, especially at the community level.

Current remote sensing assets now support wildland fire management for tactical and strategic purposes. Global and national estimates of burned areas are needed, and there is a critical need for sensors with better spatial, temporal and radiometric resolutions than the current assets, which are not designed specifically to detect fires. Another area where operational Earth observation capabilities could be implemented is conservation and biodiversity assessment. The effectiveness of protected areas and progress toward the Convention on Biological Diversity (CBD) 2010 targets could be monitored with remote sensing combined with ground truthing.

Remote sensing has been demonstrated to be an effective tool for mapping and monitoring changes in forest cover and extent. When combined with ground measurements, these changes can be used to estimate carbon emissions and stocks. It is important to note that existing ground measurements are often limited, particularly in developing countries. In this context, the Symposium endorses the proposed GEO Task on Forest Carbon Tracking and recommends strong links to ongoing related Tasks on forest and land cover and on capacity building.

Future enhancements in forest monitoring can be achieved through the further development of LIDAR, radar and thermal capabilities. Particularly lacking is a global LIDAR mission to fill a critical gap in data on vegetation height, structure, biomass and biodiversity. This would lead to improvements in biomass estimation and characterization of forest degradation in support of carbon cycle studies and monitoring. Hyperspectral sensing will improve the monitoring of

invasive species, forest health and ecosystem services. As always, remote sensing needs to be integrated with in-situ monitoring and will require efforts to build capacity for using Earth observation data.

The Symposium recommended improved access to and use of data sets and derived products through the adoption of standards for all spatial data sets. Recommendations are made for GEO standards regarding data formats, meta-data standards, and data and systems interoperability. The Symposium further reinforced the need for long-term continuity for operational observation systems because effective, sustained monitoring is impossible without it. In this regard, the Symposium supports the Land Surface Imaging Virtual Constellation being developed by the Committee on Earth Observing Systems (CEOS).

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1 Introduction

Forest ecosystems are amongst the Earth's greatest natural resources. They provide a multitude of benefits to society, ensuring environmental and human health, water quality and quantity, biodiversity, timber resources and forest products. Forest ecosystems, however, are globally threatened. Because the knowledge of the extent and condition of critical forest ecosystems is largely inaccurate, improved Earth observations are needed to bridge the gaps in forest assessment and monitoring

The goal of the Group on Earth Observations (GEO) is to construct the Global Earth Observation System of Systems (GEOSS) by proactively linking existing and planned observation systems around the world and supporting the development of new systems where gaps currently exist. These observation systems are vital for understanding the Earth system and enhancing human health and wellbeing, alleviating poverty and other forms of human suffering, protecting the global environment, reducing disaster losses, and achieving sustainable development.

GEOSS is simultaneously addressing nine areas of critical importance to people and society:

1. Reducing losses from disasters
2. Environmental effects on human health
3. Management of energy resources
4. Climate change
5. Water resource management
6. Weather
7. Terrestrial, coastal and marine ecosystems
8. Sustainable agriculture and desertification
9. Biodiversity

GEO is coordinating international efforts to build GEOSS, and this emerging public infrastructure is interconnecting a diverse and growing array of instruments and systems for monitoring and forecasting changes in the global environment. This "system of systems" supports policymakers, resource managers, science researchers and many other experts and decision-makers. GEO coordinates a multitude of complex and interrelated issues simultaneously. This cross-cutting approach avoids unnecessary duplication, encourages synergies between systems and ensures substantial economic, societal and environmental benefits.

Comprehensive forest mapping and monitoring is a primary objective of GEO. Therefore, Brazil's National Institute for Space Research (INPE) and a number of forest monitoring institutions sponsored the First GEO Forest Monitoring Symposium to promote the integrated observation and monitoring of forest extent, condition and ecological services. The symposium was held from 4-7 November 2008 at Foz do Iguaçu, Brazil. Approximately 72 participants attended representing 25 countries (Appendix 1).

The main goal of the Symposium was to consolidate the GEOSS approach for a systematic and integrated Forest Monitoring System of Systems that ensures coordination, facilitates and promotes data sharing, inter-operability, and improves the ability of forest monitoring to address relevant issues. Additional goals were to promote communication and collaboration among various communities working on different forest related themes, and to strengthen the focus on forest observation world-wide.

The Symposium agenda provided a forum where GEO task teams and key institutions worldwide furthered their programmes of work as they relate to forest observation (Appendix 2). The Symposium was designed to help participants achieve a greater understanding of the current

status of, and requirements for critical forest characterization and monitoring, including carbon and biomass, biodiversity, fire, water, fragmentation and degradation, and stress and damage. A total of 70 presentations were delivered. Presentations can be found at the Symposium website http://www.dpi.inpe.br/geoforest/. The key intended outcome was to advance the integrated characterization, assessment and monitoring of forests.

Following this introduction the report is divided into six sections. Section two reviews the status of forest related tasks in the GEO work plans. Tasks are then linked to reports of ongoing forest observation activities at global, regional and national levels. Section three describes the needs of several user communities of forest observations, which are new to the GEO, but have interests in the GEOSS.

The next three sections, four, five and six provide a more in depth synthesis of the needs and requirements for forest observations included in the tasks of the GEO 10-year work plan, and are divided into three thematic areas, sections respectively: Four) Biodiversity, Invasive Species, Forest Ecology and Protected Areas; Five) Forest Biomass and Carbon; and Six) Forest and Land Cover Dynamics, including effects of fire and agriculture. Section seven provides a summary of the workshop and recommendations for action by a number of identified organizations. Status of GEO Forest Related Tasks and Links to Ongoing Forest Observation Activities

This includes an introduction to the forest-related activities in the GEO Framework, as well as a review of three recent workshops and technical meetings relevant to GEO forest monitoring. Reports are included on forest monitoring approaches and activities at the global scale, as well as several regional and national forest inventory and mapping programs on several continents. The section is concluded with the perspectives from several user groups of forest observations, including foundations, donors, NGOs, and communities.

1.1 Overview of Forest-Related Tasks in the GEO Framework

José Achache provided an overview of the GEO Committees and explained the approach and overview of the 2009-2011 Work Plan. He emphasized that existing observing systems show important duplications. At the same time, user requirements point to significant observation gaps, which is a focus of the forest symposium (Figure 1).

Figure 1. Forest monitoring is a realization of the cross-cutting dimension of GEOSS.

Douglas Muchoney provided an overview of the GEO Forest Observation Current Tasks related to ecosystems and biodiversity. He reviewed the forest observation aspects of current GEO tasks in the areas of Ecosystems, Global Data Sets, Biodiversity, including the GEO Biodiversity Observation Network, and Community of Practice. He reviewed a number of networks and their data systems, and explained how GEO features can support improved interoperability between these systems (Figure 2).

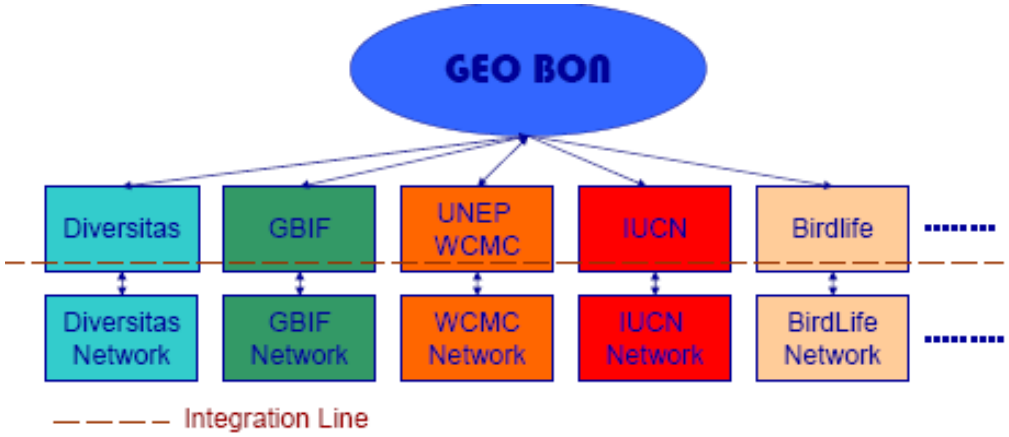

Figure 2. GEO BON Network of Networks.

Michael Brady presented the status of the GEO Forest Community of Practice with a focus on the tasks related to land cover, fire and Carbon. He described the intent and current status of seven tasks in the work plan.

He also explained the process being used by the GEO User Interface Committee to establish a GEO process for identifying critical Earth observation priorities common to many GEOSS societal benefit areas (Figure 3). The process involves scientific and technical experts, taking account of socio-economic factors, and building on the results of existing systems' requirements development processes.

Critical Earth Observation Priorities		Currently Available	
		Yes	No
Available in Future	Planned	Good situation	In waiting
	No Plan	Possible crisis	Major gap

Figure 3. Current and future states of critical forest observation priorities.

The GEO tasks requiring forest-related observations are listed as follows:

1. Ecosystem Observation and Monitoring Network
2. Human Dimension of Ecosystem Utilization and Conservation
3. Global Data Sets - Global Phenology Data
4. Ecosystems Classification and Mapping
5. Biodiversity Observation Network
6. Invasive Species Monitoring System
7. Biodiversity Community of Practice
8. Forest Mapping and Change Monitoring
9. Global Land Cover
10. Virtual Constellations-Land Surface Imaging sub task
11. Implementation of a Fire Warning System at Global Level
12. Key Terrestrial Observations for Climate
13. Regional Networks for Ecosystems
14. Pilot Communities of Practice
15. Global Carbon Observation and Analysis System - Forest Carbon Tracking

1.2 Global, Regional and National Level Activities with Links to GEO Forest Tasks

Recent Workshops and Technical Meetings

Alan Grainger summarized the Workshop on Remote Sensing Requirements for Global Forest Monitoring at London from 20-21 Oct 2008.

Curtis Woodcock reviewed the GOFC-GOLD Land Cover Symposium held at Jena from 13-17 October 2008.

Jinlong Fan UN REDD Workshop on Monitoring, Assessment and Verification at Washington from 16-17 September 2008.

Global and Regional Forest Monitoring Programs

Adam Gerrand reviewed the FAO Forest Resource Analysis, including the Regional and Global Forest Monitoring and Assessment 2010 programme.

Michael Brady presented the activities of the panel for Global Observation of Forest Cover and Land Dynamics – GOFC-GOLD.

Hugh Eva reviewed the activities of Globcover at the EC-JRC.

National Level Forest Inventory and Monitoring

Forest National Inventories Status (Introduction by the Chair)

Dalton de Morisson Valeriano presented INPE's Long-Term Forest Monitoring in Brazil.

Ken Brewer provided an overview of the National Forest Inventory of the US Forest Service.

Michael Brady reviewed the National Forest Inventory in Canada.

Wardoyo presented the Indonesia National Forest Inventory.

2 Key Users of Forest Observations and Their Needs

2.1 Key Users Perspectives

Roger Sedjo reviewed the activities of Foundations with a focus on the work of Resources for the Future.

Per Erik Skrøvseth discussed the observational needs of the donor community with a focus on national agencies such the Norway Space Centre.

Carlos Alberto Scaramuzza of WWF Brazil reviewed the activities of IGOs and NGOs and their activities in Brazil.

Rafael Salles Valente discussed the needs of communities and local users, with a focus on the activities of FAS.

Thelma Krug provided the viewpoint of Brazil on recent developments in forest monitoring in the UNFCCC.

2.2 Synthesis of User Groups of Forest Observations

Two main groups of users are identified: a) decision and policy-makers working at various spatial scales who need information suited to their needs; and b) scientists studying global change, land use change and related areas who need data to feed into their models of deforestation, biodiversity, and carbon loss, the impacts of climate change on biodiversity and ecosystem services. They in turn will produce further studies that will provide information to scientific deliberations, such as IPCC, which will in turn provide information to policy-makers that are tailored to their needs.

The information and data requirements of various types of decision-makers and scientists can be divided into three major categories:

1. Thematic Data: Derivative data products produced from one or more source of remotely-sensed data such as land cover type.

2. Earth Observation Data: Primary satellite, aerial and in situ observations used to derive thematic data products.

3. Ancillary Data: Collected by other means than remote sensing, such as field sampling of vegetation and soils. They are generally compiled into digital spatial databases.

Users were categorized as:

- International Treaties and Conventions

- Intergovernmental Institutions and Mechanisms
- Non-Governmental Organizations (NGOs)
- National Governmental
- Academic / Research Institutions
- Private and Industry

The data required by each category of user is described below.

International Treaties and Conventions

There are a number of international conventions and intergovernmental organizations that require Earth observation data and their derivative thematic products to meet their program objectives relevant to forests, biodiversity and climate change. This report details the requirements of some of the major activities, and looks to finding commonalities in their requirements and to recommend actions that the Group on Earth Observations can undertake to ensure the reliable delivery of Earth observation data, including satellite, airborne and in situ data to support them.

Convention on Biological Diversity (CBD)

The Convention on Biological Diversity was adopted in 1992 in Nairobi, Kenya and open for signature at the Rio Earth Summit. Its objectives are the conservation and sustainable use of biodiversity and the fair and equitable sharing of benefits arising out of the use of genetic resources. The Convention has 191 Parties.

Through decision VII/30, the Conference of the Parties to the Convention on Biological Diversity (CBD) adopted a framework of goals, targets and indicators to enhance the evaluation of progress toward the 2010 biodiversity target. It contains a number of indicators for immediate testing; Earth observation is in a strong position to support the testing and operationalization of these indicators. Within the focal area of status and trends of the components of biological diversity, two indicators for immediate testing were identified that are relevant to Earth observation:

- Trends in extent of selected biomes, ecosystems and habitats
- Trends in abundance and distribution of selected species.
- Within the focal area of sustainable use, the relevant indicator is the following:
- area of forest, agricultural and aquaculture ecosystems under sustainable management.
- Focal area of threats to biodiversity:
- Numbers and cost of alien species
- Focal area of ecosystem integrity and ecosystem goods and services:
- Connectivity/fragmentation of ecosystems
- Incidence of human-induced ecosystem failure
- Health and well-being of people living in biodiversity-based resource dependent communities

Decision VIII/15 further specified the framework of goals and targets for the thematic programmes of work of the Convention, including the programme of work on forest biodiversity.

Ramsar Convention on Wetlands

The Convention on Wetlands, adopted in Ramsar, Iran, in 1971, is an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. There are presently 158 Contracting Parties to the Convention, with 1828 wetland sites, totalling 169 million hectares, designated for inclusion in the Ramsar List of Wetlands of International Importance (http://www.ramsar.org/). Article 1.1 of the Convention defines wetlands as "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres". This definition includes, inter alia, wet forests.

The 10th meeting of the Conference of the Parties to the Ramsar Convention identified, through resolution X.10, the high priority tasks for the Ramsar Scientific and technical review Panel (STRP) for 2009-2012. This list includes the development of the Global Wetland Observing System (G-WOS), drawing on collaboration, data and analyses from, inter alia, relevant Earth observation programmes and agencies and serving to support relevant Ramsar effectiveness indicators, such as the indicator on status and trends in ecosystem extent.

United Nations Convention to Combat Desertification (UNCCD)

The United Nations Convention to Combat Desertification (UNCCD) was adopted in 1994 in Paris. It has 193 Parties. Its objectives are to combat desertification and mitigate the effects of drought in countries experiencing serious drought and/or desertification, particularly in Africa. Dry forests and woodlands are particularly important for the application and implementation of the Convention for many countries. The 8th meeting of the Conference of the Parties to the UNCCD in 2007 adopted a Strategic Plan for the Convention. The Strategic Plan includes operational objective 3 on science, technology and knowledge, the outcomes of which are particularly relevant for Earth observation:

- Outcome 3.1: National monitoring and vulnerability assessment on biophysical and socioeconomic trends in affected countries are supported.
- Outcome 3.2: A baseline based on the most robust data available on biophysical and socioeconomic trends is developed and relevant scientific approaches are gradually harmonized.
- Outcome 3.3: Knowledge on biophysical and socio-economic factors and on their interactions in affected areas is improved to enable better decision-making.
- Outcome 3.4: Knowledge of the interactions between climate change adaptation, drought mitigation and restoration of degraded land in affected areas is improved to develop tools to assist decision-making.
- Outcome 3.5: Effective knowledge-sharing systems, including traditional knowledge, are in place at the global, regional, subregional and national levels to support policymakers and end users, including through the identification and sharing of best practices and success stories.

- Outcome 3.6: Science and technology networks and institutions relevant to desertification/land degradation and drought are engaged to support UNCCD implementation.

United Nations Framework Convention on Climate Change (UNFCCC)

The United Nations Framework Convention on Climate Change (UNFCCC) was adopted in 1992 and entered into force in 1994. It has 192 Parties. The Convention sets an ultimate objective of stabilizing greenhouse gas concentrations "at a level that would prevent dangerous anthropogenic (human induced) interference with the climate system."

The contribution of emissions from deforestation to anthropogenic greenhouse gas emissions was acknowledged at the 13th Conference of the Parties in Bali. Decision 2/CP.13 set out approaches to stimulate action for reducing emissions from deforestation in developing countries (REDD). This encouraged Parties to improve inter alia data collection, estimation of emissions from deforestation and forest degradation, monitoring and reporting. Of relevance to Earth Observation systems, indicative guidance stressed that estimates of reductions or increases of emissions should be results based, demonstrable, transparent and verifiable, and estimated consistently over time. Parties were invited to submit their views on how to address outstanding methodological issues including, inter alia, assessments of changes in forest cover and associated carbon stocks and greenhouse gas emissions, incremental changes due to sustainable management of the forest, demonstration of reductions in emissions from deforestation, including reference emissions levels, estimation and demonstration of reduction in emissions from forest degradation.

The potential for Earth Observation Systems to assist in REDD implementation has been discussed at this meeting and several other SBSTA methodological workshops. At the 14th Conference of the Parties in Poznan, the Draft conclusions proposed by the Chair of SBSTA called for a continuation of work on methodological issues related to REDD, requested a technical paper on the cost of implementing methodologies and monitoring systems, and invited Parties to submit information on needs for technical and institutional capacity-building and cooperation in, inter alia, ground-based and remote sensing approaches.

The IPCC Good Practice Guidelines encourage the use of both ground-level and remote sensing data in producing national inventories for Land Use, Land Use Change and Forestry (LULUCF) under the Convention, the Kyoto Protocol, and the CDM. Decision 2/CP.13 and the Draft conclusions of SBSTA recommend the use of these guidelines in REDD methodological guidance.

Intergovernmental Institutions and Mechanisms

United Nations

UNESCO World Heritage Programme - UNESCO's World Heritage mission is to:

- Encourage countries to sign the World Heritage Convention and to ensure the protection of their natural and cultural heritage
- encourage States Parties to the Convention to nominate sites within their national territory for inclusion on the World Heritage List
- Encourage States Parties to establish management plans and set up reporting systems on the state of conservation of their World Heritage sites

- Help States Parties safeguard World Heritage properties by providing technical assistance and professional training
- Provide emergency assistance for World Heritage sites in immediate danger
- Support States Parties' public awareness-building activities for World Heritage conservation
- Encourage participation of the local population in the preservation of their cultural and natural heritage
- Encourage international cooperation in the conservation of our world's cultural and natural heritage

UNESCO's Man and the Biosphere Programme - The Man and the Biosphere Programme (MAB), proposes an interdisciplinary research agenda and capacity building aiming to improve the relationship of people with their environment globally. Launched in the early 1970s, it notably targets the ecological, social and economic dimensions of biodiversity loss and the reduction of this loss. It uses its World Network of Biosphere Reserves as vehicles for knowledge-sharing, research and monitoring, education and training, and participatory decision-making. Biosphere reserves are sites recognized under the Man and the Biosphere Programme, which innovate and demonstrate approaches to conservation and sustainable development. They are under national sovereign jurisdiction, yet share their experience and ideas nationally, regionally and internationally within the World Network of Biosphere Reserves. There are 531 sites worldwide in 105 countries.

UNEP World Conservation Monitoring Centre (UNEP-WCMC) - The UNEP World Conservation Monitoring Centre is the biodiversity assessment and biodiversity policy support arm of the United Nations Environment Programme, the world's foremost intergovernmental environmental organization. The Centre has been in operation for over 25 years, providing objective, scientifically rigorous products and services to help decision makers recognize the value of biodiversity and apply this knowledge to all that they do. The Centre's core business is locating data about biodiversity and its conservation, interpreting and analysing that data to provide assessments and policy analysis, and making the results available to both national and international decision makers and businesses.

Since 1981 UNEP-WCMC has been compiling information from regional, national and sub-national agencies on the protected areas of the world and makes it available to the global community. This information is then used to produce a comprehensive global dataset (the World Database on Protected Areas [WDPA]) and support the development of relevant indicators. The WDPA is a joint project of UNEP and IUCN, produced by UNEP-WCMC and the IUCN World Commission on Protected Areas working with governments and collaborating NGOs.

The World Database on Protected Areas (WDPA) is the most comprehensive global spatial dataset on marine and terrestrial protected areas available. Protected areas are internationally recognised as major tools in conserving species and ecosystems. Up to date information on protected areas is essential to enable a wide range of conservation and development activities.

Earth observation data and information are needed to report on the conventions (e.g. CBD, MDGs) and provide information and analyses for UNEP, governments and other partners.

Food and Agriculture Organisation of the United Nations (FAO) - The Food and Agriculture Organization of the United Nations leads international efforts to defeat hunger. Serving both developed and developing countries, FAO acts as a neutral forum where all nations meet as equals to negotiate agreements and debate policy. FAO is also a source of knowledge and information. FAO helps developing countries and countries in transition modernize and improve agriculture, forestry and fisheries practices and ensure good nutrition for all. Since 1945, FAO has focused special attention on developing rural areas, home to 70 percent of the world's poor and hungry people.

Global Forest Resources Assessment 2010 - Like the last assessment (FRA 2005) FRA 2010 will provide a comprehensive picture of the extent of forests and other wooded land, their condition, management and uses; this time covering all the seven thematic elements of sustainable forest management.

Moreover, FRA 2010 is designed to cover the forest-related information needs for monitoring progress towards the 2010 Biodiversity Target of the Convention on Biological Diversity (CBD), the Global Objectives on Forests of the United Nations Forum on Forests (UNFF) and the Millennium Development Goals.

The FRA 2010 process was officially launched during a global workshop in Rome (3 to 7 March 2008).

In addition to the traditional collection of country information through questionnaires and thematic studies, a complementary global remote sensing survey will be carried out in partnership with countries and other organizations. It aims at improving the knowledge about land use change dynamics, including deforestation, afforestation, and natural expansion of forests.

As part of the Global Forest Resources Assessment 2010 (FRA 2010), FAO and its member countries and partners will undertake a global remote sensing survey of forests. This survey is aimed at substantially improving the knowledge on land use change dynamics over time, including deforestation, afforestation and natural expansion of forests. Building on the large existing network of national correspondents and other contacts and using a participatory process, the capacities of developing countries to determine historical rates of deforestation and to monitor current and future rates using a common framework and agreed methodology will be considerably strengthened.

Development Banks

- The World Bank
- Regional Development Banks

Global Earth Observing System of Systems (GEOSS)

GEOSS-Framework Benefit 9: Biodiversity issues include "…the condition and extent of ecosystems,

Distribution and status of species

Implementing GEOSS will unify many disparate biodiversity-observing systems and create a platform integrate biodiversity data with other types of data.

Millennium Development Goals

The Millennium Development Goals (MDGs) are eight goals to be achieved by 2015 that respond to the world's main development challenges. The MDGs are drawn from the actions and targets contained in the Millennium Declaration that was adopted by 189 nations-and signed by 147 heads of state and governments during the UN Millennium Summit in September 2000.

Earth observation could contribute to many of the MDGs, in particular to Goal 7: Ensure environmental sustainability. In particular Targets 7A and 7B on "Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources" and "Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss" could benefit from earth observation. Indicators 7.1 "Proportion of land area covered by forest", 7.6 "Proportion of terrestrial and marine areas protected" and 7.7 "Proportion of species threatened with extinction" are likely to rely heavily on earth observation data.

Non-Governmental Organizations (NGOs)

The World Conservation Union (IUCN) - IUCN, primarily through its World Commission on Protected Areas (WCPA), stages a World Park Congress every 10 years for the benefit of the conservation community and the world at large. The Congress brings together a large global assembly of PA specialists, managers and experts to focus on the state of the planet's PAs, the challenges they face and the opportunities before them. The WCPA acts as a catalyst for global PA action and recommends future directions for these special places on earth.

GOFC-GOLD -

Conservation Organisations

WWF, Conservation International, TNC, Birdlife International etc.

National Governments

National Forest Inventories

National Donor Agencies

Academic / Research Institutions

Private and Industry

Private Foundations

Industry

The next three sections provide a more in depth synthesis of the needs and requirements for forest observations included in the tasks of the GEO 10-year work plan, and are divided into three thematic areas, respectively: Section 4) Biodiversity, Invasive Species, Forest Ecology and Protected Areas; section five) Forest Biomass and Carbon; and Section 6) Forest and Land Cover Dynamics, including effects of fire and agriculture.

3 Observation Priorities for GEO Tasks Related to Forest Biodiversity

3.1 Links to ongoing GEO Tasks and Progress Reports

Doug Muchoney provided an overview of tasks on GEO Biodiversity Network, GEO Invasive Species and GEO Ecosystems.

Bradley Reed reviewed the progress of the GEO Global Phenology Network.

Steffan Fritz of the IIASA Forestry Program presented views on Socio-economic benefits of GEOSS with focus on Biodiversity and Ecosystems.

C. Perez presented on Forest Fauna.

Doug Muchoney provided an overview of GEO Protected Areas Assessment and Monitoring.

J. Scharlemann described the observational needs of the UNEP - WCMC and the WDPA.

D. Cordero reviewed the observational needs of IUCN.

Mario Hernandez reviewed the observational needs of UNESCO.

3.2 Protected Areas

Protected areas are defined by the International Union for Conservation of Nature (IUCN) as "a clearly defined geographical space recognised, dedicated and managed, through legal or other effective means to achieve the long-term conservation of nature with associated ecosystem services and cultural values". Protected areas (PAs) are internationally recognised as a major tool for conserving species and ecosystems, providing a range of goods and services essential to human wellbeing.

The value and importance of PAs are recognised by both the Convention of Biological Diversity (CBD) and the Millennium Development Goals (MDGs), both calling for assessment and monitoring of PA status and trends to be achieved by 2010 (and 2012 for the marine areas). These targets call for "at least 10 per cent of each of the world's ecological regions to be effectively conserved and areas of particular importance to biodiversity to be protected" (CBD Decision VII/30) and targets for forests state that "at least 10 per cent of the world's forest types" should be effectively conserved by 2010 (CBD Decision VIII/15).

Observation Data Requirements

Earth Observation priorities for Protected Areas

Knowing the location of global protected areas, available via the World Database on

Protected Areas (www.wdpa.org), is the first step towards assessing these targets. To assess whether biodiversity and ecosystems are effectively protected by PAs and plan for the future of PA management, requires information on the status and trends of habitats and ecosystems within PAs.

We therefore need GEO-referenced time-series of satellite imagery for within all PAs, together with simple tools to detect and measure change. This information is needed to assess progress towards the CBD and MDG targets as well as to assess PA management effectiveness. If timely

detection of habitat change was available and accessible (e.g. forest fire monitoring), this would permit intervention by PA managers to ensure effective biodiversity protection within protected areas.

Users Protected Area managers, nations, policy makers, e.g. protected area indicators for MDGs and CBD targets

Requirement status and trends of habitat within protected areas

Primary Data: GEO-referenced time series in all PAs, classified imagery and simple tools to measure change

EO data: Landsat, or similar and radar data for areas with high cloud cover frequency where current EO data are not available

Ancillary data:PA extent, validation and calibration datasets

Source: Landsat, or similar and radar data for areas with high cloud cover frequency

Spatial scale: 50m or finer

Temporal scale: 1970s – continuously ongoing

Timeliness: annual update (and near daily for early warning system, e.g. fire detection)

Gaps: information for cloud forests

Descriptions: global protected areas, 106,000 sites, ca. 18,000,000 km2

3.3 Summary and Recommendations

1. Supporting the IUCN Global Species Assessments by providing baseline geospatial thematic data and web-based analytical tools.

2. Initiating a Global Phenology Network

This activity will address how terrestrial ecosystems are changing in terms of vegetation phenology, which impacts biodiversity, net primary productivity, species distribution, albedo, biomass and ultimately the global climate. It will develop a mechanism or mechanisms through a collaborative process to collect in situ observations of phenology and identify and generate satellite-derived phenological / temporal metrics. The activity will further test models for describing the phenological characteristics of natural and modified ecosystems, so that they might be better monitored using remote sensing and in situ techniques. There are a number of existing phenology networks, principally in North America and Europe that are not currently well coordinated. This will offer a mechanism to bring a level of standardization to collecting this important ecosystem parameter and establish a Community of Practice. It will also provide an important mechanism for expanding phenology networks throughout the world.

3. Initiating the GEO Protected Areas Assessment and Monitoring programme.

4. Initiate a Data Outreach Programme for Forests

Develop Intergovernmental, NGO, Governmental, Industry and Academia to provide hardware, software, data and training to critical sites globally

5. Initiating “Composite Analysis” demonstration projects at key, representative sites to demonstrate the benefits of conducting studies on carbon and biomass, biodiversity and water co-benefits simultaneously.

6. Operationalize a Species Assessment System providing geo-spatial data and tools for modelling the distribution of key species.

7. Mobilize additional resources to sped-up completion of the GEO Ecosystem Map

8. Use the GEO Ecosystem Map and the WDPA to conduct a global protected areas gap analysis.

9. Initiate an Ecosystem Trends Analysis System to regularly update the status of global ecosystems based on key indicators (fragmentation, land cover and land use change etc.).

10. Rapidly develop recommendations for key actions concerning the availability, use and access to data (national, industry, academic) to enable 1-9 above.

4 Observation Priorities for GEO Tasks Related to Forest Biomass and Carbon

4.1 Context and Overview

Per Erik Skrøvseth reviewed the proposed GEO Task on Forests and Carbon.

Thelma Krug introduced REDD and associated estimation and monitoring issues.

4.2 Global and National Activities

National Experiences

Alex Held reviewed the Australian National Carbon Accounting System: Elements and functionality.

Wardoyo presented the National Carbon Accounting System of Indonesia.

Barbara Koch explained the EC Approach to Forest Biomass Monitoring.

Ken Brewer and Charles Dull presented the US Forest and Carbon Experiences.

Michael Brady presented Canada’s Carbon Accounting System.

Global Initiatives

Alex Held presented the International Forests and Carbon Initiative.

Curtis Woodcock explained the programme of the Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD).

4.3 Methodologies and Approaches to Estimate Forest Change, Biomass and Carbon

Carlos de Souza reviewed Global Methodological Coordination Activities – GOFC-GOLD Sourcebook. He also presented models to estimate carbon in the Brazilian Amazon, and comparison with other data sets.

Marc Steininger discussed deforestation results in Central and South America.

Niro Higuchi presented Biomass and Carbon in the Brazilian Amazon. He also discussed estimates of biomass and carbon from destructive sampling: General allometric equations for Amazonia.

4.4 Coordination of Existing and Planned Remotely Sensed Systems for Carbon Forest Assessment

John Townshend described the CEOS land Surface Imaging Virtual Constellation concept.

National Systems, Continuity, General Data Availability

Fernando Ramos explained CBERS.

Curtis Woodcock reviewed Landsat plans.

Michael Brady reviewed the RADARSAT programme and plans to provide access to the 15-year archive of data.

4.5 Discussion and Refinement of Proposed Task Description

GEO has launched a new task called "Forest Carbon Tracking", to start in January 2009, to demonstrate and provide confidence in the use of Earth Observation tools and methodologies towards achieving global operational forest monitoring goals, including those of REDD. Overall it is the consensus of the thematic group on "Forest Biomass and Carbon" in this symposium, that current EO systems and processing methods have already demonstrated in a number of cases to effectively map and quantify changes in forest cover and extent, as input together with in-situ observations, to forest carbon estimation and prediction tools and emission budgets (examples Brazil, Australia and India). Ongoing refinement and wider implementation of forest change mapping methods will be coordinated through GEO, in particular to address data access and possible gaps in data continuity over cloud-affected areas. This will include coordination of data acquisition by space-borne radar systems currently in space or close to be launched. Direct estimation of aboveground forest biomass via earth observation technologies was seen as a promising area of research and development, which complemented with airborne LIDAR systems and selected in-situ measurements and future space-borne LIDAR and interferometric synthetic aperture is expected to deliver considerable improvements in direct biomass estimation.

Current Needs

It can be demonstrated through a selected project and national examples that it is possible to report on GHG emissions from deforestation and forest degradation – both for historical periods (since mid 70s) and for the foreseeable future, starting with relatively simple yet verifiable methods that combine in situ measurements, carbon models and remote sensing data.

However insufficiently consistent, long-term satellite data availability in many countries, combined with the complexity in current analysis methods, are still hindering wider international use and adoption remote sensing for annual monitoring of forest change, biomass and carbon estimation, in carbon emissions reporting, biofuel production and international programs for climate change mitigation.

This can also be caused by:

1. Insufficient quantification of uncertainties and recognition that readily available approaches will need to be improved over time.
2. Technical dimensions vary in response to changes or indecision on key policy decisions
3. Some definition problems on what constitutes degraded forests and how this is to quantified

Focus of the group has been on observations for broader forest area change monitoring and aboveground biomass estimation, but recognizes need to enhance the understanding of changes in other components of forest-related carbon pools, such as soil carbon, in particular peat soils).

Unlike estimation of forest area change, assessment of biomass and carbon stocks and their change is heavily dependant on ground truth, including conversion of standing volume and its relation to biomass and carbon stock.

Thus the goal for this GEO activity is to provide a basis for continuous improvements in delivery of reliable information services of suitable consistency, increased accuracy and continuity to support global and national forest cover, biomass and carbon tracking. Research and development will be fostered to further improve capabilities for mapping forest characteristics such as forest type, structure and degradation, and thus significantly advance the precision of reporting of GHG emissions. Most promising evolving technologies are interferometric SAR, LIDAR and hyperspectral. Research and development is needed for transitioning current mostly airborne systems to operational satellites in the service of this GEO activity.

Extra text:

REDD is still not agreed

Other benefits are forest conservation

Estimation of forest biomass and associated carbon stock

Afforestation, reforestation, secondary vegetation, IPCC guidelines approach

Inclusion of non-GHGs

Avoided emissions from biomass burning

Avoided emissions from management of peat land

Carbon Markets also an incentive

4.6 Summary and Recommendations

A number of key deficiencies in meeting user needs were identified:

The integration of optical and SAR data are needed to improve remote sensing estimates over cloudy areas.

Model parameterization issues, when implemented in other areas, require closer coordination with other GEO tasks such as climate.

Indonesia: Assembly of datasets for parameterization of carbon models (remote sensing, climate, soils, etc.). Understanding carbon and GHG emissions over peat soils. Kalimantan is recommended as a primary pilot study site for model and remote sensing implementation.

Bio-energy: Biomass Energy Europe: Insufficient quality of input data to calculate potential biomass estimates across Europe. Role of earth observation? No standard methods for analysis: direct or indirect methods, need for community decision on which method to adopt? Definition of forest and non-forest maps?

US Forest and Carbon: phased approach from remote sensing? and field inventories; modelling of soil carbon may be a limitation at present?

Canada: terminology issues in attribution of forest changes/disturbance/forest management. Optical data continuity, multi-sensor integration.

Brazil: forest definition and use of remote sensing data may still be difficult, forest area assessments with remote sensing, carbon/biomass estimation via remote sensing is currently not seen as adequate at this point; national forest inventory is limited, GEO can anticipate need for direct biomass estimation directly.

Improved ways to report on accuracy of land-use change mapping results (e.g. for 'area of change').

Early technical guidance on emerging remote sensing technologies (e.g. SAR, LIDAR) and methodologies (e.g. forest degradation monitoring, selective logging, leakage areas).

Linkages to biodiversity (hotspots, key biodiversity areas).

Value of traditional air photography?

Linking biodiversity sites with Forest carbon validation initiatives.

Involvement by NGO's in GEO Tasks is recommended.

Need larger regional projects/hubs.

Automation of processing.

Linking Amazon biomass field sites with LIDAR.

Uncertainty in forest biomass estimates for use in carbon models and very low spatial agreement.

Encourage space agencies to provide data in some pre-processed agreed format (e.g. orthorectified products) and do not force users to do this pre-processing.

Demonstration of biomass product to space agencies? Or first forest cover change or both?

How about future capability for forest change detection and fire?

Promote launch and multi-national continuity of other technologies (e.g. LIDAR).

Promote more use of CBERS free data, promote similar data policies in other missions.(also like LDCM policy).

What are implications for requirements in capability development?

GOFC-GOLD Regional Networks Program is one approach.

Issues with access to broadband internet (e.g. access to free Landsat data).

Kopernicus (GMES) Sentinel-2 data policy also possibly 'free data policy.

SAR data missions are of value, in particular if archives are also provided free of cost, and design of systematic acquisition strategies for future missions will be critical for this task.

High-resolution imagery (sub-1m) are needed to verification and validation purposes.

Data accessibility major potential problem if raw (or L1t) data to be freely available

GEO Task on Forest Carbon Tracking (CL-09-03b)

The Group endorsed proposed GEO Task CL-09-03b (Forest Carbon Tracking), and made the following recommendations:

Encourage establishment of several bilateral or multilateral arrangements to develop regional reference test-sites, to demonstrate capability in support of forest cover change reporting and associated climate policy needs:

Includes end-to-end projects at country/regional level, with an initial emphasis on tropical developing countries and later expansion to temperate forested areas and other lands.

Coordination of the production of reference and demonstration datasets.

Form a global network of national forest monitoring systems, underpinned by common data, easy access and agreed standards and methodologies.

Consolidation of observational requirements and associated products required for forest change monitoring, via consultation and commissioning of special report by expert groups such as GOFC-GOLD.

Coordinated assessment of analysis tools and methodologies, including current accuracy and capabilities, limitations, uncertainties (GOFC-GOLD).

Coordination of systematic, long-term observations, including securing satellite continuity by space agencies. Includes engagement with the CEOS Land Surface Imaging Constellation program and acceleration of establishment of a focused radar sub-team for LSI (received commitment by CEOS SIT and CEOS Plenary in 2008).

Initiate regional capacity building activities to further improve access to observations, datasets, tools and processing and interpretation expertise, via bi-lateral or multilateral government arrangements or associated to ongoing FAO FRA field validation programs.

Combine, where possible, with other Themes' demonstrator sites and LTER's/Protected Areas/Biodiversity 'hotspots'. For example, link to current Forest Monitoring Networks. Coordinate and expand national forest inventory datasets (where available) into a global network

of forest inventories for model parameter estimation and verification. Better integration of terrestrial, aerial and satellite data in form of multi-phase or multi-level inventory systems

GEO and GEO Members

The following recommendations were made concerning GEO and GEO Members:

Member countries and participating organizations should endorse the current Forest Carbon Tracking task, and commit resources and technical experts to undertake specific work plan.

GEO should invite international NGO community to actively support and engage in this task.

GEO, via CEOS and member space agencies, should coordinate access to observational data and associated long-term satellite continuity, plus available processing tools, to give countries the capacity to undertake annual reporting of forest area change and trends (if they so desire). This includes:

Request CEOS and the Land Surface Imaging Constellation Program to coordinate long-term, operational availability and access to medium resolution optical satellite image data (and in particular standard land-cover change products).

Advocate for systematic acquisition of Synthetic Aperture Radar data at required data specification (wavelength, acquisition mode) for specific use in operational forest change mapping.

GEO should invite GOFC-GOLD to provide analysis and advice on relevant data processing tools and methodologies, and facilitate development of accuracy estimates for remote-sensing based forest and land cover change monitoring.

GEO member countries commit to establish large-area reference sites (linked to regional capacity-building activities, national forest agencies) for example demonstration of capability, accuracy and rapid implementation, , and in the future incorporate evolving technologies (LIDAR, SAR interferometry) and regional capacity building programs [include future acquisition of selected airborne InSAR and LIDAR datasets for methodology development and verification]

GEO Member countries must assist in ultimate establishment of a ‘network of national forest cover change monitoring systems’ (or rather coalesce current programs), underpinned by this common data, easy access and agreed standards and methodologies.

GEO member countries should seek to improve global capacity in forest cover monitoring, data interpretation and emissions reporting, through establishment of a network of regional training activities for capacity-building on forest area change reporting.

GEO will support the objective of a comprehensive global forest stock volume assessment. Successful examples in boreal forests exist, that can be improved further with advanced radar, LIDAR, and very high resolution data. Research needed to demonstrate feasibility to other climatic zones (tropical, temperate)

GEO will support the establishment/maintenance of a network of forest reference sites (both permanent and non-permanent sites) across a range of climatic zones and forest biomes for biomass and carbon stock measurements, for validation purposes and other needs of the GEO community (e.g., biodiversity).

GEO will support the development of new methods to facilitate the biomass and carbon stock assessments (including technical/observational as well as social approaches).

GEO will support the development of soil carbon datasets.

REDD

Specific recommendations concerning REDD are:

GEO will support requirements for continuous observations for assessment of forest area change in relation to REDD, from mid 70s into the future, in developing countries.

GEO will support further research into development of approaches to estimate forest biomass and associated carbon stocks, in developing countries.

GEO will support the development of alternative approaches to address estimating forest cover changes in cloud affected areas.

GEO will support readily access to radar data for REDD, as well as availability of high temporal resolution optical data (at appropriate spatial resolution) to facilitate timely detection of forest cover changes.

GEO will support systems to facilitate processing and timely data/products distribution to users.

Steps:

Improved capability will be demonstrated to showcase country-based examples (and capacity) of estimation of rates of forest area change and degradation, biomass and carbon accounting that combine remote sensing, models and in-situ measurements [e.g. Brazil, India, Australia, Canada]

1. Provide accuracy estimates for current observation capabilities and processing methodologies
2. Seek the necessary operational data access/continuity and processing tools to assist other counties in applying similar capabilities to their needs, and thus form a 'network of national forest monitoring systems' underpinned by common data, easy access and agreed standards and methodologies (?)
3. Establish large-area reference sites for e.g. demonstration of capability, accuracy and rapid implementation, and in the future incorporate evolving technologies (LIDAR, SAR interferometry) and regional capacity building programs [include future acquisition of selected airborne InSAR and LIDAR datasets for methodology development and verification]

5 Observation Priorities for GEO Tasks Related to Forest and Land Cover Dynamics

5.1 Overview of Global Scale GEO Tasks

Jinlong Fan provided a Description and links to ongoing GEO tasks and progress reports.

Michael Brady described the Global Land Cover Task.

Hugh Eva discussed the TREES and GLOBCOVER programmes and their contribution to the GEO land cover task.

Adam Gerrand described the Forest mapping and change monitoring in the FRA 2010.

Jinlong Fan presented the GEO Agriculture Monitoring task.

Alberto Setzer explained the Global Fire Early Warning System task.

Michael Brady reviewed the GEO Forest Community of Practice task.

5.2 Regional Activities

Cover mapping

Adam Gerrand presented the Africover mapping programme of FAO.

Brad Reed described North America Land Cover mapping activities.

Michael Brady presented the Africa CARPE activities on behalf of Matt Hansen.

Ken Brewer described Fire and Agriculture mapping in the USA.

Alberto Setzer discussed the Redlatif Regional Network on Fire monitoring in Latin America.

Curtis Woodcock presented the results of GOFC-GOLD Circumboreal land cover workshop.

Linkages to Forest inventory systems

Ken Brewer presented the systems used in the USA and North America.

5.3 National activities

Tropics

Dalton Valeriano presented the forest cover mapping activities in Brazil.

Hermawan and Wardoyo presented the forest cover mapping activities in Indonesia.

Temperate

Ken Brewer and Chuck Dull presented the forest cover mapping activities in the USA.

Jinlong Fan presented the forest cover mapping activities in China.

Peter Caccetta presented the forest cover mapping activities in Australia.

Boreal

Michael Brady presented the forest cover mapping activities in Canada.

Alexander A. Maslov presented the forest cover mapping activities in Russia.

5.4 Methods

Ruedi Wagner discussed current applications of air borne sensors in forest monitoring and mapping.

Niels Wielaard discussed emerging radar techniques to support regional and local scale monitoring of tropical.

5.5 Summary and Recommendations

Forest Cover issues were grouped according to the following and are related to the four GEO transverse areas 1) Data organization (sequential): Acquisition/access, Higher order products, Interpreted products such as land cover change, and Future capabilities; and 2) Capacity building (cross cutting).

Acquisition/access

GEO should encourage space agencies to maintain capabilities of research sensors such as MODIS; e.g. for fire. This should be frame in terms of requirements, not specific systems.

GEO should give priority to a dedicated systematic data collection strategy, including integrated acquisition for SAR and optical data.

GEO should establish an initiative for open (free!) data access. This could be accomplished by decentralising activities – regional networks for direct access (the direct readout community not sufficiently organised at present) – GEO could provide single link between satellite and direct readout community e.g. CBERS and open data policies.

GEO should provide support for continuity of sensors for specific products; e.g. hot spots and fire scars.

GEO should approach receiving stations and commercial data suppliers for open access to archival data.

GEO should facilitate annual [more frequent?] free or low cost supply of a set of standard Landsat-like remote sensing products.

GEO should promote operational tactical and strategic observation systems which are needed for rapid responses. One important example is fire hot spots and burned area globally as well as deforestation. These data should be at Landsat like resolution. Such systems should provide direct broadcast capability.

GEO should encourage space agencies to coordinate SARs missions to provide broad range of frequencies, polarimetric and interferometric capability for demonstration sites

Higher order products

GEO should work with CEOS and other relevant organisations to define a set of standards for all higher order products for preprocessing (including minimum geolocation accuracy) should be defined so as to facilitate the input and subsequent processing of the data. Similar requirements should be set for meta-data which need to be in standard format (compliant with international standards) and reflect the whole processing chain. These should also be implemented in the reprocessing of data from local receiving stations and from other sources (e.g. commercial enterprises).

Pre-processing needs to be tailored to meet operational and strategic requirements.

A specific effort is required to develop a SAR best practice guides so as to integrate these data with existing optical land cover mapping/monitoring, particularly for tropical regions.

GEO should work with the relevant authorities to facilitate the worldwide availability of 30 m DEM (as could be released from SRTM).

For land and forest cover, GEO should promote the harmonisation of legends using the Land Cover Classification system (LCCS) of the UN-FAO.

Interpreted products such as land cover change

Land cover change products at the final user application level are required to be produced on an annual base specifically for forested areas worldwide, with a resolution equal to or finer than 30 meters.

These products should include burnt forest areas, afforestation, reforestation and deforestation estimates. A shared dataset of validation and training data for selected sites representative of the forests being monitored is also required.

For critical areas a period of less than 3 months is recommended as a processing limit for the land cover change product evaluations in order to allow practical actions to restrict illegal deforestation.

The data, comprising sample sites, meta-data, user manuals, standards for uncertainty and final products, should be periodically updated.

Future capabilities

GEO should support emerging user needs and reporting duties worldwide at multiple scales with advanced technologies such as LIDAR, hyperspectral satellites and SAR (e.g. biomass, soil moisture, forest degradation) with standardized methodologies.

Required products: Yearly assessment of Forest cover, Forest Cover Change and Burned Area and regular updates of Flooded Forest and Forest Biomass. These assessments and updates should be at Landsat-like resolution with interim steps at coarser resolution (250 m – 500 m), according to the requirements for UNFCCC and REDD carbon accountings.

Capacity building

GEO should strongly promote regional networks and strengthen mechanisms to support capacity building particularly in developing regions (e.g. success of fire networks in Latin America).

GEO should enhance communication and outreach to policy and decision makers.

GEO should provide information on the capacity of EO use globally, across forest thematic areas and larger Societal Benefit Areas (SBAs).

6 Summary of Key Issues, Gaps and Priorities

The GEO Forest Monitoring Symposium was convened with the goals of linking existing and planned forest observation systems around the world, identifying new systems where gaps currently exist, and improving access to, and use of, in situ, aerial and satellite Earth observations.

The Symposium concluded that several existing products clearly demonstrate the ability of Earth observations to improve global forest monitoring. However, creating sustained operational systems based on these capabilities will require considerable additional efforts and major investments in capabilities and capacity. These improvements in forest monitoring will be more widely realized with the adoption of stronger open-data policies. The collection of radar data in specified areas with high cloud frequencies to compliment optical data is specifically important.

For many developing countries, significantly increased efforts in capacity building are needed to derive the full benefits of the data, especially at the community level.

Current remote sensing assets now support wildland fire management for tactical and strategic purposes. Global and national estimates of burned areas are needed, and there is a critical need for sensors with better spatial, temporal and radiometric resolutions than the current assets, which are not designed specifically to detect fires. Another area where operational Earth observation capabilities could be implemented is conservation and biodiversity assessment. The effectiveness of protected areas and progress toward the Convention on Biological Diversity (CBD) 2010 targets could be monitored with remote sensing combined with ground truthing.

Remote sensing has been demonstrated to be an effective tool for mapping and monitoring changes in forest cover and extent. When combined with ground measurements, these changes can be used to estimate carbon emissions and stocks. It is important to note that existing ground measurements are often limited, particularly in developing countries. In this context, the Symposium endorses the proposed GEO Task on Forest Carbon Tracking and recommends strong links to ongoing related Tasks on forest and land cover and on capacity building.

Future enhancements in forest monitoring can be achieved through the further development of LIDAR, radar and thermal capabilities. Particularly lacking is a global LIDAR mission to fill a critical gap in data on vegetation height, structure, biomass and biodiversity. This would lead to improvements in biomass estimation and characterization of forest degradation in support of carbon cycle studies and monitoring. Hyperspectral sensing will improve the monitoring of invasive species, forest health and ecosystem services. As always, remote sensing needs to be integrated with in-situ monitoring and will require efforts to build capacity for using Earth observation data.

The Symposium recommended improved access to and use of data sets and derived products through the adoption of standards for all spatial data sets. Recommendations will be made for GEO standards regarding data formats, meta-data standards, and data and systems interoperability. The Symposium further reinforced the need for long-term continuity for operational observation systems because effective, sustained monitoring is impossible without it. In this regard, the Symposium supports the Land Surface Imaging Virtual Constellation being developed by the Committee on Earth Observing Systems (CEOS). The full Symposium report will be completed by the end of this year.

6.1 Recommendations

A set of synthesized, common outcomes and recommendations were developed and are reported below by the GEO Transverse (cross-cutting) areas: User Interface; Capacity and Capacity Building; Science and Technology; and Architecture and Data.

User Interface

GEO should enhance communication and outreach to policy and decision makers. A rigorous outreach programme should be promoted so that policy makers are enlightened as to products that GEOSS can offer.

GEO should provide information on the capacity of EO use globally, across forest thematic areas and larger Societal Benefit Areas (SBAs).

GEO should promote collaboration between government and private sectors in terms of carbon trade business and links with biodiversity conservation.

Incorporate Forest Symposium results in user process (User Interface Committee, User Requirements Activity – US-06-01) to identify priority observations.

Capacity and Capacity Building

GEO should support promotion of capacity building in developing nations.

Training of users should be provided.

GEO should facilitate biodiversity monitoring protocols.

GEO member countries seek to improve global capacity in forest cover monitoring, data interpretation and emissions reporting through the establishment of a network of regional training activities for capacity-building on forest area change reporting [role of donors.

GEO members should strongly promote regional networks and strengthen mechanisms to support capacity building particularly in developing regions (e.g. success of fire networks in Latin America. GEO should re-emphasize the importance of existing Regional Network task in the Workplan. GEO should strongly promote regional networks and strengthen mechanisms to support capacity building particularly in developing regions (e.g. success of fire networks in Latin America).

Initiate regional capacity building activities to further improve access to observations, datasets, tools and processing and interpretation expertise, via bi-lateral or multilateral government arrangements or associated to ongoing FAO FRA field validation programs.

Science and Technology

LIDAR research in support of biomass and biodiversity should be actively promoted.

Architecture and Data

Data Continuity:

Maintain capabilities of research sensors such as MODIS for fire. This should be framed in terms of requirements, not specific system.

Data Sharing:

Approach receiving stations and commercial data suppliers for open access to archival data.

Data Acquisition/Access:

Establish an initiative for global, open (free!) moderate-resolution data access.

Strengthen global/regional data distribution mechanisms (e.g. GEONetcast, SERVIR, and Sentinel Asia) for efficient delivery of medium resolution forest cover-change products. This will require coordination with GEO members.

Facilitate annual free Landsat-like dataset.

Approach receiving stations and commercial data suppliers for open access to archival data.

For land and forest cover, FAO should further promote the harmonisation of legends using the Land Cover Classification system (LCCS) among GEO members.

Data Products:

- Higher order products
- Interpreted products such as land cover change

Future capabilities:

GEO member countries nominate to establish large-area reference sites (linked to regional capacity-building activities, national forest agencies) for e.g. demonstration of capability, accuracy and rapid implementation, , and in the future incorporate evolving technologies (LIDAR, SAR interferometry) and regional capacity building programs [include future acquisition of selected airborne inSAR and LIDAR datasets for methodology development and verification]

6.2 Immediate Action Items

The following activities were identified for several organizations as immediate actions needed to support and maintain Earth Observations for forest characterization and monitoring.

Note: LC = Land Cover, C = Carbon and B = Biodiversity Themes.

Space Agencies: CEOS and LSI task team

- Maintain capabilities of research sensors such as MODIS; e.g. for fire. Frame in terms of requirements, not specific system (LC)
- Encourage space agencies to coordinate SAR missions to provide broad range of datasets for demonstration sites (LC). Sub tasks include:
    - Establish a radar sub-team for CEOS LSI Constellation in consultation with the GEO Virtual Constellation Task Team (C*)
    - Formulate an integrated acquisition strategy, and specific agencies' commitment for Optical and Radar in support of land cover change in the tropics (CEOS LSI Constellation Task Team) (C+LC)

UN Agencies

- For land and forest cover, FAO should further promote the harmonisation of legends using the Land Cover Classification system (LCCS) among GEO members. (LC)

GEO National Members, Task Teams and Committees

Data acquisition/access:

- Establish an initiative for global, open (free!) moderate-resolution data access. (LC)
- Strengthen global/regional data distribution mechanisms (e.g. GEONetcast, SERVIR, Sentinel Asia) for efficient delivery of medium resolution forest cover-change products in coordination with GEO members. (C)
- Facilitate annual free Landsat-like dataset (LC)
- Approach receiving stations and commercial data suppliers for open access to archival data, possibly through the Constellation Task Team. (LC)

Higher order products:

- Establishment of Regional Reference Test Sites, including shared datasets of validation and training data for selected sites representative of the forests being monitored. (GEO Carbon Tracking Task Team (coordination w/GEO members and donors) (C, LC)
- GEO should work with CEOS (CEOS Working Group on Calibration/Validation) and other relevant organizations to define a set of standards for all higher order products for pre-processing (including minimum geolocation accuracy). Similar requirements should be set for meta-data which need to be in standard format (compliant with international standards) and reflect the whole processing chain. (LC)
- Support an effort on best practices for integration of SAR and optical data in support of land cover change monitoring in tropics, possibly coordinated through GOFC-GOLD. (LC)
- Facilitate the worldwide availability of 30 m DEM. (LC)
- Initiate a Global Phenology Networkas described in the GEO 2009-2011 Work Plan. (B)
- Compile existing datasets on species distributions through the GEO Biodiversity Observation Network. (B)

Interpreted products:

- Members to produce land cover change products at the final user application level are required to be produced on an annual basis, specifically for forested areas, with a resolution equal to or finer than 30 meters. These products should include burnt forest areas, afforestation, reforestation and deforestation estimates. (LC)
- Promote integrated GEO Pilots
- Initiate "Composite Analysis" demonstration projects at key, representative sites to demonstrate the benefits of conducting studies on carbon and biomass, biodiversity and water co-benefits simultaneously.

Capacity building:

- GEO members should strongly promote regional networks and strengthen mechanisms to support capacity building particularly in developing regions (e.g. success of fire networks in Latin America). GEO should re-emphasize importance of the existing Regional Network Task. (LC)
- Develop Intergovernmental, NGO, Governmental, Industry and Academia to provide hardware, software, data and training to critical sites globally

GOFC-GOLD

- Observational Requirements for REDD (including radar) through the Working Groups on REDD (GOFC-GOLD and UN-REDD) in coordination with CEOS LSI. (C)
- Coordination of Analysis Tools and methodologies, including current accuracy and capabilities, limitations and uncertainties (Working Groups on REDD – GOFC-GOLD, UN-REDD) (C)
- Hold a Workshop on Ecosystem in Coordination with GEO, UNEP and IUCN. (B)
- Workshop on Ecosystem Condition in Coordination with GEO, UNEP and IUCN. (B)
- Sponsor a biomass workshop and consider forming a Biomass working group to further develop biomass observations and mapping (LC)

NGOs

- IUCN – convene with WCMC in late ’09 a protected areas workshop (B)
- Initiate the GEO Protected Areas Assessment and Monitoring programme.
- Use the GEO Ecosystem Map and the WDPA to conduct a global protected areas gap analysis.

GEO Forest Community of Practice

- Incorporate Forest Symposium results in user process to identify priority observations (B,C, LC)
- Initiate a Data Outreach Programme for Forests

Research Funding Organizations

- Lidar research in support of biomass and biodiversity should be promoted.

Commercial Providers

- Approach receiving stations and commercial data suppliers for open access to archival data perhaps through the Constellation Task Team. (LC)

Philanthropic Organizations

- Philanthropic Organizations should be included in all relevant activities.

7 Appendices

Appendix 1. GEO Forest Monitoring Symposium Participants

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Appendix 2. GEO Forest Monitoring Symposium Agenda

Nov 04 – Pacifico Room

Plenary Session–Introduction and Status of Forest Programmes

8h00–9h00 **Check–in and Registration**

9h00–10h00 Welcome and Introduction

- Plenary Address – Mr. Tasso Azevedo, Director General, Brazil Forest Service
- Charge and Schedule – Dalton de Morisson Valeriano and Douglas Muchoney
- GEO – José Achache
- INPE – João Vianei Soares

10h00–10h30 **Recent Workshops and Technical Meetings Reports**

- Remote Sensing Requirements for Global Forest Monitoring Workshop (London, 20–21 Oct 2008) – Alan Grainger
- 3rd GOFC–GOLD Land Cover Symposium (Jena, 13–17 Oct 2008) – Curtis Woodcock
- UN REDD Workshop on Monitoring, Assessment and Verification (Washington, 16–17 Sept 2008) – Jinlong Fan

10h30 – 11h00 Break

11h00 – 12h00 **Forest–related activities in the GEO Framework**

- GEO Forest Observation Current Tasks – Douglas Muchoney
- GEO Forest Community of Practice – Michael Brady
- Approach and Overview of the 2009–2011 Workplan – José Achache
- GEO Committees overview – José Achache

12h00 – 1h30 Lunch

1h30 – 2h45 **Forest Monitoring Programs**

- FAO Forest Resource Analysis – Adam Gerrand, FAO
- Global Observation of Forest Cover – Michael Brady, GOFC–GOLD
- Globcover – Hugh Eva, EC–JRC
- New sampling approaches for forest monitoring – TBD

2h45 – 3h45 **National Forest Inventories** – Chair: Karan Deo Singh, FAO

- Forest National Inventories Status (Introduction by the Chair)

- INPE Long-Term Forest Monitoring – Dalton de Morisson Valeriano
- National Forest Inventory USFS – Ken Brewer
- National Forest Inventory Canada – Michael Brady
- Regional and Global Forest Monitoring and Assessment programme – FAO – Adam Gerrand
- Indonesia Forest Inventory – Wardoyo, MOF

3h45 – 4h00 Break

4h00 – 4h45 **Key Users Perspectives** – Chair: Alan Grainger

- Foundations – Roger Sedjo, RFF
- Donors – Per Erik Skrøvseth, Norway Space Centre)
- IGO and NGO, Carlos Alberto Scaramuzza, *WWF Brasil*
- Communities and Local Users, Rafael Salles Valente, FAS

4h45 – 5h30 **Update on Recent Developments** – Thelma Krug, INPE

6h30 – 7h30 **Welcome Drink with Talk on Perspective on Forests through Time** – Roger Sedjo, RFF

Nov 05 – Concurrent Thematic Break-Out Groups

8h30 – 9h00	Welcome and Introduction to Concurrent Thematic Break-Out Groups
9h00 – 10h00	Concurrent Thematic Break-Out Groups
10h00 – 10h30	Break
11h00 – 12h00	Concurrent Thematic Break-Out Groups
12h00 – 1h30	Lunch
1h30 – 3h00	Concurrent Thematic Break-Out Groups
3h00 – 3h30	Break
3h30 – 5h30	Concurrent Thematic Break-Out Groups
5h30	Adjourn Day 2

Nov 06 – Morning – Thematic Break-Out Groups and Group Reports

8h30 – 9h15	Plenary-Thematic Group updates
9h15 – 11h30	Concurrent Thematic Break-Out Groups, report drafting
12h00 – 1h30	Lunch, afternoon break / Field Trip

Nov 07 – Morning – Report Preparation

8h30 – 9h00	Reports from the Thematic Break-out Groups and discussion
9h00 – 10h00	"Climate Action for Poverty Reduction- CPR Roundtable" by the World Agroforestry Centre – Nairobi, Kenya
10h00 – 10h30	Break
10h30 – 12h00	3 Thematic & New Immediate Actions Group Brea-out Meetings (report refinement, links to presentations & transverse areas)
12h 00 – 1h30	Lunch

Nov 07 – Afternoon – Plenary, 4 Reports and Synthesis

1h30 – 3h00	**Reports from 3 Thematic & Immediate Actions Group**
3h00 – 3h30	**Break**
3h30 – 4h30	Discuss report final draft, any further writing assignments, report to GEO Plenary, future GEO forest events?
4h30	**Adjourn and Close of Symposium**

Thematic Group Session Outlines

Thematic Group 1 Biodiversity, Invasive Species, Forest Ecology and Protected Areas

(Chairs: Doug Muchoney, Jorn Scharlemann, Mario Hernandez, Bradley Reed)

Montevideo Room

1. Description and links to ongoing GEO tasks and progress reports
   - Overview of GEO Biodiversity Network – Doug Muchoney, USGS
   - Overview of GEO Invasive Species – Doug Muchoney, USGS
   - GEO Global Phenology Network – Bradley Reed, USGS
   - GEO Ecosystems – Doug Muchoney, USGS
   - Socio-economic benefits of GEOSS with focus on Biodiversity and Ecosystems – S. Fritz, IIASA Forestry Program
   - Forest Fauna – C. Perez, U. of New East Anglia, UK
   - Overview of GEO Protected Areas Assessment and Monitoring – D. Muchoney
     - UNEP – WCMC and the WDPA – J. Scharlemann, UNEP-WCMC
     - IUCN – D. Cordero, IUCN
     - UNESCO – Mario Hernandez
2. Discussion on Task interactions – Task Leads

Thematic Group 2 Forest Biomass and Carbon

(Chairs: Thelma Krug, Roger Sedjo and Alex Held)

Pacifico Room

1. Context and Overview:
   - Proposed GEO Task on Forests and Carbon –Per Erik Skrøvseth, Norway Space Centre
   - Introduction to REDD and associated estimation and monitoring issues – Thelma Krug, INPE

2. Global and National Activities:

National Experiences

   - Australian National Carbon Accounting System: Elements and functionality – Alex Held, CSIRO – Australia
   - National Carbon Accounting System of Indonesia – Ministry of Environment or Forestry – Indonesia
   - The EC Approach to Forest Biomass Monitoring – Barbara Koch
   - US Forest & Carbon Experiences – Ken Brewer and Charles Dull, USFS
   - Canada Carbon Accounting System – Michael Brady

Global Initiatives

   - The International Forests and Carbon Initiative – Alex Held, CSIRO – Australia
   - Global Observation of Forest and Land Cover Dynamics – Curtis Woodcock, GOFC-GOLD

3. Methodologies and Approaches to Estimate Forest Change, Biomass and Carbon – 2 hours

- Review of Global Methodological Coordination Activities – GOFC-GOLD Sourcebook – Carlos de Souza, IMAZON
- Models to estimate carbon in the Brazilian Amazon, and comparison with other data sets – Carlos de Souza, IMAZON
- Deforestation results in Central and South America – Marc Steininger, Conservation International
- Biomass and Carbon in the Brazilian Amazon – Niro Higuchi, INPA
- Estimates of biomass and carbon from destructive sampling: General allometric equations for Amazonia – Niro Higuchi – National Institute for Amazonia Research

4. Coordination of Existing and Planned Remotely Sensed Systems for Carbon Forest Assessment –The CEOS land Surface Imaging Virtual Constellation concept (CEOS, USGS, John Townshend, GOFC-GOLD)

- National Systems, Continuity, General Data Availability
  - CBERS – Fernando Ramos, INPE
  - Landsat – Curtis Woodcock
  - RADARSAT
  - ALOS
  - IRS
- Continuity, data needs (spatial and temporal) resolution of future systems, identification of current gaps in for use in routine monitoring forest change and biomass
- Establishment of Global Test Sites for Sensor Evaluation, and Processing Methodology Refinement.

5. Discussion and Refinement of proposed task description

Thematic Group 3 Forest and Land Cover Dynamics (including effects of fire and agriculture

(Chairs: Michael Brady, Dalton Valeriano, Alberto Setzer)

Assuncion Room

1. Overview of global scale GEO tasks

- Description and links to ongoing GEO tasks and progress reports – Jinlong Fan, GEO Sec
- Global Land Cover – Michael Brady, GOFC-GOLD and Tom Loveland, USGS
  - GLOBCOVER – Hugh Eva, EC-JRC
- Forest mapping and change monitoring – FRA 2010 – Adam Gerrand, FAO
  - TREES – Hugh Eva, EC-JRC
- Agriculture Monitoring – Jinlong Fan, GEO

- Global Fire Early Warning System – Alberto Setzer, INPE
- Forest Community of Practice – Michael Brady, CFS

2. Regional activities:

Cover mapping

- Corine (tbd)
- Africover – Adam Gerrand, FAO
- North America Land Cover – Ken Brewer and Chuck Dull, USFS
- Africa CARPE – Matt Hansen, SDSU
- Fire and Agriculture – Ken Brewer, USFS
- Regional Networks on Fire – Alberto Setzer, INPE and Redlatif
- Circumboreal: results of GOFC-GOLD workshop – Curtis Woodcock, GOFC-GOLD

Linkages to Forest inventory systems

- Europe – tbd
- North America – Ken Brewer, USFS

3. National activities:

Tropics

- Brazil – Dalton Valeriano, INPE
- Africa – tbd
- Indonesia – Hermawan or Wardoyo, DEPHUT

Temperate

- USA – Ken Brewer and Chuck Dull, USFS
- China – Jinlong Fan, GEO
- Australia – Peter Caccetta, CSIRO

Boreal

- Canada – Michael Brady, CFS
- Russia – Alexander A. Maslov, RAS/Scanex

4. Methods

- Current applications of sensors in forest monitoring and mapping – Ruedi Wagner, Leica Geosystems AG
- Emerging radar techniques to support regional and local scale monitoring of tropical forests – Niels Wielaard, SarVision and Dirk Hoekman, Wageningen University

5. Discussion on Task Integrations, observation gaps, data needs, synthesis

Appendix 3. Selected Bibliography of Observational Requirements for Forests

The following is a preliminary list of reports, which include observational requirements in support of forest monitoring:

GOFC-GOLD Report Series, including land cover and fire product requirements, and strategy documents, 1997-2008 (http://www.fao.org/gtos/gofc-gold/series.html)

IGOL Report, 2007

GEO Agricultural Monitoring Report, 2007

GCOS ECV standards for UNFCCC SBSTA systematic observations agenda, 2008

FRA 2010 Global Survey Document, 2008

GEOSS Reference Document, 2005

Land Cover User Assessment Project Report, Canada, 2008

ESA Globcover User Needs Report, 2008

GSE Forest monitoring user assessment

Report of the 2nd West Africa Regional Network Meeting on Earth Observation and Environmental Change, Accra, 2007