Report of the Meeting of the Land Cover Characteristics and Changes Implementation Team

Toulouse, France

11 - 13 February 2002

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Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD) is a coordinated international effort to ensure a continuous program of space-based and in situ forest and other land cover observations to better understand global change, to support international assessments and environmental treaties and to contribute to natural resources management.

GOFC-GOLD encourages countries to increase their ability to measure and track forest and land cover dynamics by promoting and supporting participation on implementation teams and in regional networks. Through these forums, data users and providers share information to improve understanding of user requirements and product quality.

GOFC-GOLD is a Panel of the Global Terrestrial Observing System (GTOS), sponsored by FAO, UNESCO, WMO, ICSU and UNEP. The GOFC-GOLD Secretariat is hosted by Canada and supported by the Canadian Space Agency and Natural Resources Canada. Other contributing agencies include NASA, ESA, START and JRC. Further information can be obtained at
http://www.fao.org/gtos/gofc-gold

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Global Observation of Forest Cover (GOFC)/Global Observation of Landcover Dynamics (GOLD). A panel of the Global Terrestrial Observing System (GTOS)

15 March, 2002

1.0 Introduction

The first team meeting of the GOFC/GOLD Land Cover Characteristics and Changes Implementation Team (LCCC-IT) was held 11-13 February 2002 in Toulouse, France. The Centre National d'Etudes Spatiales, the French space agency, hosted the meeting.

The objective of the Implementation Team (IT) meeting was to develop a concerted plan of activities to prototype operational forest and land cover monitoring systems using both satellite and in situ observations. These systems are envisioned as being comprised of three observatories; Carbon, Ecosystems and Forest Status. Current projects and programs that can contribute were identified and new supporting initiatives were planned.

The Land Cover Characteristics and Changes Implementation Team meeting included representatives from other GOFC Implementation Teams, Regional Networks and representatives from other major contributors to and users of GOFC/GOLD related initiatives such as CEOS, GTOS, FAO, AFRICOVER, and the Millennium Ecosystem Assessment. The participation of these groups has helped to connect and coordinate Implementation Team activities within the larger research framework.

Appendix A presents the meeting program. A substantial portion of the first day was dedicated to review of the Implementation Team priorities, overall implementation strategy, and the several ongoing and contributory projects that can be involved. Special attention was given to the need for calibration, validation and general harmonization of products as this is considered critical for the overall objections of the GOFC/GOLD effort.

During the second day of the workshop the ongoing efforts of the Regional Networks were detailed. Thereafter, the day was focused on outlaying the critical elements and questions surrounding the establishment of observatories for Carbon, Ecosystems, and Forest Status.

The third day of the meeting focused further on discussion of the proposed observatories. Specific action items and initiatives necessary for implementing the Implementation Team strategies and achieving the GOFC/GOLD goals were developed.

2.0 Participants

The meeting included representatives from other GOFC/GOLD Implementation

Teams, and the various Regional Networks. Additional representatives from both stakeholding and interested user-community entities such as CEOS, GTOS, FAO, ASIACOVER, AFRICOVER and the Millennium Ecosystem Assessment attended so as to help connect and coordinate the Implementation Team activities within the larger research framework. (See Appendix 1 for the complete list)

The GOFC/GOLD Land Cover Characteristics and Changes Implementation Team meeting was attended by 31 scientists from 12 countries.

- Belgium
- Canada
- Congo
- France
- Germany
- Italy
- Japan
- Kenya
- Malaysia
- Russia
- United Kingdom
- United States

3.0 Potential Contributory Projects

The GOFC/GOLD Land Cover Implementation Team's proposed initiative to build operational forest and land cover monitoring systems in the form of three observatories (Carbon, Ecosystems and Forest Status) could be supported by several ongoing international Land Cover (LC) and Land Cover Change (LCC) projects. Furthermore, the products from this system of global observation would directly feed into other important global assessments such as the Millennium Ecosystem Assessment (MA), the Global Terrestrial Observing System (GTOS) among others.

Below are synopses of several potential contributory projects which could be integral in the proposed observation strategy for monitoring carbon, ecosystems and forest status. The presentations that were made at the Land Cover and Characteristics Change Implementation Team meeting are available for viewing on the following website (http://bsrsi.msu.edu/gofc-gold/toulouse/).

VEGA 2000 : (Dr. Jeanjean, CNES) Expected outcomes of VEGA 2000 include the production of global maps such as land cover and burnt area maps, with specific reference to the implementation and control of the international conventions (UNFCCC, CCD, CB). Of particular importance to the GOFC/GOLD community is a new data policy implemented in October 2001 which now

provides open access to standard archive VEGETATION products for the world scientific community on a « COFUR » basis (Cost of Fulfilling User Request). The data are provided free by ftp or at the media cost for other formats (http://free.vgt.vito.be).

GLC 2000 and TREES: (Dr. Mayaux and Dr. Bartalev, JRC) Global Land Cover (GLC) 2000 will use SPOT VEGETATION data from VEGA 2000 to develop 1 km resolution maps of both land cover and burnt area that are globally consistent and uniform for the year 2000. The data will use a common hierarchical classification scheme based on FAO-LCCS and be freely available to all users and contributors.

Tropical REsources and Environment Monitoring by Satellite Project (TREES) is providing a prototype of tropical deforestation monitoring through a stratified sampling of 100 high resolution scenes designed to define deforestation hot spots and provide deforestation figures at global and regional level.

USGS Land Cover: (Dr. Loveland, USGS EDC) Overview of selected USGS Land Cover Projects. Projects included comparisons of SPOT and MODIS for large-area land cover quantification, comparisons of fine- and mid-resolution map data for estimating coarse-resolution land cover classes, regression- and decision-tree derivation of flexible land cover characteristics and the North America portion of the Global Land Cover (GLC) 2000 project and the national fuel and vegetation mapping and characterization of the LANDFIRE Project. Major deliverable products of potential interest to the GOFC/GOLD community include, Land cover characterization, Natural vegetation types/transitions, Natural vegetation structure classification, Accuracy assessment, Fire potentials, Fire regime, Fire regime condition class, Fuel condition class, Ecosystem status and FARSITE & FOFEM input data layers.

Forest Fractional Cover and MODIS: (Dr. DeFries, UMD) A multi-resolution approach for change detection, using coarse-resolution percentage tree cover estimates, is a particularly promising technique for dealing with the challenges inherent in measuring and monitoring continuous field representations of forest cover characteristics with repeated observations. Automated analysis of coarse resolution data is capable of identifying major, broad-scale characteristics and changes in forest cover. The combined use of coarse and fine resolution data is effective for monitoring changes in forest cover. MODIS data has a strong potential for estimating percentage tree cover frequently across wide regions. Overall, the approach is scalable and capable of linking field measurements with coarse resolution satellite data for calibration

The Global Rain Forest Mapping Project: (Dr. Rosenqvist, NASDA) The Global Rain Forest Mapping (GRFM) and Global Boreal Forest Mapping (GBFM) Projects are designed to acquire temporally and spatially homogeneous coverages of JERS-1 SAR data and provide a “snap shot” of the state of tropical and boreal forests. The projects provide regional image mosaics at 100 m pixel

size, semi-continental image mosaics at 500m and 2 km ground resolutions, as well as dual season, co-registered radar texture mosaics. Products are available to research and educational groups free of charge. Full resolution datasets are available only to the Science team.

SIBERIA: (Dr Schmullius, Friedrich-Schiller University) The SIBERIA-II project uses multiple sensors to provide greenhouse gas accounting in Northern Eurasia. The project is a large-scale demonstration of the usefulness Earth Observation (EO) data for environmental monitoring. The project uses a multi-sensor (multi-temporal, multi-spatial) approach with data from 12 different satellites. There is synergetic use of optical-optical data, and optical-SAR EO data to retrieve level 1 products. Fusion of level 1 products with ground data is used to generate level 2 products. Level 1 products include, land cover and change maps, biomass maps, snow cover, freeze/thaw, wetland monitoring and GBFM thematic products (SAR land-cover map). Level 2 products include, disturbance mapping (e.g. fire), Photosynthetic Available Radiation (PAR), afforestation, reforestation and deforestation monitoring, and net primary productivity (NPP) by land class.

Landsat Temperate Forest Monitoring: (Dr. Woodcock, BU) Large-area monitoring of temperate forest change can be done using high resolution (Landsat) imagery and a generalized automated change detection technique (Fuzzy ARTMAP). Accuracies of methods based on generalization match conventional methods. The use of methods based on generalization allows for more efficient or frequent monitoring of large areas. Lower image cost and increased availability of Landsat 7 data, combined with methods based on generalization, make it practical to begin regional to continental, and eventually global, monitoring of temperate forest change at high spatial resolutions. Although optimal atmospheric correction techniques vary with datasets, in general, simpler atmospheric correction methods result in the highest overall classification and change detection accuracies.

Landsat Tropical Forest Monitoring: (Dr. Qi, MSU/BSRSI) A new GOFC/GOLD project on Tropical Forest Monitoring will provide data, data products and information for tropical forest assessment and management. The project will evaluate the application of data and products to tropical forest management needs through collaboration with several forestry management agencies in tropical countries, coordinated through a network of collaborating scientists. Products at three processing levels will be provided. Level one products will include raw Landsat (TM and ETM+), VEGETATION, and MODIS data. Level 2 products will include 30 m and 1 km Landsat materials that are georeferenced, atmospherically corrected and normalized for sun and view angles. Spatial accuracy will be ±60 m. Level 3 products will include continuous field estimates of Forest Density (FD) such as forest fractional cover, estimated green leaf area index and Fraction of absorbed Photosynthetic Available Radiation (fPAR).

ENAMORS: (Dr. Lambin, University Catholique de Louvain). ENAMORS stands for European Network for the development of Advanced Models to interpret Optical Remote Sensing data over terrestrial environments. It is the name of a project originally run by a consortium of universities and research centers involved in Earth Observation using space-based remote sensing techniques in the optical domain. The overall purpose of ENAMORS is to promote the development, implementation and evaluation of advanced methodological tools and techniques to analyze satellite remote sensing data in Europe. This is achieved through the organization of international conferences on the methodology and applications of remote sensing, the distribution of these tools and techniques whenever possible, the demonstration of their applicability and usefulness, support for visits between and exchanges of personnel amongst the members of the consortium, and other activities deemed useful to create or reinforce a European vision and capability in this area.

FAO AFRICOVER: (Mr. Latham and Mr. Di Gregorio, FAO/UN) The Food and Agriculture Organization (FAO) AFRICOVER project makes map production faster, cheaper, more reliable and multi-user oriented AFRICOVER has developed a new global methodology for land cover thematic mapping. The LCCS (Land Cover Classification System) is a new concept of land cover classification system that is able to describe any type of land cover feature in the world at any scale or level of detail with an absolute level of standardization. LCCS is quickly becoming a world wide accepted classification system. LCCS is the official FAO land cover classification system and has been endorsed by both UNEP and IGBP. Furthermore, it is being used by several international organizations (e.g. JRC for GLC2000) and many countries. The whole methodological approach and related softwares form the AFRICOVER "thematic package". These software and information will be freely distributed to institutions, organization or single projects that want to apply the AFRICOVER methodology.

FAO ASIACOVER: (Mr. Reichert, FAO) The Food and Agriculture Organization (FAO) ASIACOVER Project will provide a regional spatially standardized database that will include information derived from in situ observations, statistics, maps, and remote sensing data. The sub-region covered in phase I includes Cambodia, China (Province of Yunnan), Lao People's Democratic Republic, Malaysia, Myanmar, Thailand and Viet Nam. The ASIACOVER database will contain the biophysical and socio-economic data necessary for the formulation of policies and strategies for food security and sustainable development. ASIACOVER is developing partnerships with other regional, international and bi-lateral institutions, such as GOFC/GOLD, UNEP, Joint Research Centre (JRC), Mekong River Commission and others working in related fields

NASDA Kyoto-Carbon Initiative: (Dr. Rosenqvist, NASDA) The NASDA Kyoto-Carbon initiative constitutes the continuation and expansion of the JERS-1 SAR Global Forest Mapping Projects (GRFM/GRBM) into the era of the Advanced

Land Observation Satellite (ALOS). The objectives of the initiative are to support the information requirements for forest and land use changes posed by the UNFCCC Kyoto Protocol and to support international efforts for an integrated global observing strategy for the terrestrial carbon cycle. The initiative is based on an extensive data acquisition strategy, primarily of the polarimeric L-band PALSAR that will provide spatially and temporally consistent data sets at high spatial resolution and adequate temporal revisit frequency for all land areas on the Earth.

Millennium Ecosystem Assessment: (Dr. Ash, MA) The Millennium Ecosystem Assessment (MA) plans to report on the extent of various ecosystem types in the year 2000. Land cover types will likely form the basis of the units of reporting and so the MA is looking to GOFC/GOLD for recommendations as to which product(s) the MA should be using. The MA is encouraging the development of suitable product by 2003, with particular emphasis on improved information on agricultural lands and improved coverage of wetland types. The MA has requested that GOFC/GOLD provide a contemporary online "catalogue" of derived products available from the remote sensing community that may be of use in the MA. The MA will establish Memoranda of Understandings (MOUs) with GOFC/GOLD and IGBP LUCC. In addition to land cover and cover change products, the MA is searching for products providing productivity measures for terrestrial and fresh water systems (e.g. NPP, aboveground carbon storage, production capacity) and Ecosystem processes monitoring (e.g. fire frequency and intensity, sediment discharge, coastal eutrophication).

Terrestrial Carbon Observation: (Dr. Cihlar, CCRS) The Terrestrial Carbon Observation (TCO) will provide systematic information on the spatial and temporal distribution of terrestrial carbon sources and sinks, and on the role of the terrestrial sinks and sources in the global carbon cycle. The objectives of the TCO are; By 2005, to demonstrate the capability to estimate annual net land-atmosphere fluxes at a sub-continental scale (10^7 km^2) with an accuracy of +/- 30% globally, and a regional scale (10^6 km^2) over areas selected for specific campaigns; By 2008, improve the performance to better spatial resolution (10^6 km^2 globally) and an increased accuracy (+/- 20%); Produce flux emission estimate maps with the highest spatial resolution enabled by the available satellite-derived and other input products; Establish and implement a process of ongoing improvements to ensure that products and information meet current and future needs and are obtained in an efficient manner; Contribute to capacity building at regional and national levels to acquire and use terrestrial carbon-related data or information.

4.0 Actions and Recommendations

4.1 Concept of the Observatories: As part of GOFC/GOLD, the Implementation Team is charged with measuring, monitoring and quantifying global and regional land cover characteristics as well as any changes in these characteristics over time. Efforts such as these require observations and, furthermore, change detection requires a series of observations that are directly comparable to each other. Therefore, in order to accomplish its assigned tasks, the Implementation Team has decided that it needs to establish observatories that are capable of assuring continuous data acquisition that is of sufficient quantity and quality. These observatories are not conceived of as physical objects or locations but instead as conceptual guidelines which provide critical specification of overall data acquisition strategies as well as the necessary data sources, classification schemes, quality, and validation for the global effort.

To address the perceived needs of the international community, the Implementation Team has resolved to develop three separate observatories that look at land cover characteristics and changes in different ways, specifically, Carbon, Ecosystems and Forest Status Observatories. The Carbon Observatory will support ongoing biogeochemical observations and modeling efforts by providing spatio-temporal information on terrestrial carbon stocks and changes that are globally comparable and validated. The Ecosystems Observatory will focus on the remote sensing of the extent, integrity, composition and change of the World's various ecosystems and provide support to such efforts and the Millennium Ecosystem Assessment. The Forest Status Observatory will provide a demonstration of improved global and regional products using new remote sensing technologies including demonstrations of regional high resolution forest/land cover maps including fine resolution fractional cover for forest degradation assessment.

4.2 Implementation Plan for the Observatories: There was a consensus by the workshop participants that there is a need to develop a coordinated research proposal that presents the conceptual outline of the Carbon, Ecosystem and Forest Status Observatories together with detailed descriptions of how to implement and operationalize each observatory. The document can provide coherence to the overall research initiative and serve as the core element of the funding strategy for the various components being developed by the Implementation Team. A funding strategy could include clusters of donors from space agencies, (e.g. NASA, CCRS, CNES, DLR, NASDA, ESA, etc.), foundations and other sources, as appropriate.

The central role of the Scientific and Technical Board (STB) in facilitating funding along the lines outlined in the Implementation Plan is viewed as critical. The funding strategy will emphasize submission of the document to the various donors to solicit their joint "buy-in" to support components or specific IT participant activities within the Plan.

The proposal components for each individual observatory will be written by core drafting teams (as working groups) together with the members of the regional networks. Methods, classification, validation, and implementation of networks as Task Teams will be addressed. After the core drafting team has outlined the proposal, writing assignments for the separate components will be made to the Implementation Team members. Full preparation is expected to take a matter of weeks/months.

4.3 Working Groups to Support the Observatories: In order to support the development of the Observatories, four specific focus areas of continued discussion were identified. These subjects were assigned to sub-groups of the Implementation Team as Working Groups that will further define the issues and approaches to be used in the Observatories. The findings of the Working Groups will provide guidance to the Implementation Team during development of the Implementation Plan for the Observatories. The specific Working Groups and assigned team members include:

- Carbon (Schmullius, Cihlar, JeanJean, Defries, Skole, Rosenqvist , Thuy)
- Land Cover (classification schemes and processing issues) (Loveland, Mayeaux, Defries, Latham)
- Land Cover Change (Defries, Lambin, Skole, Woodcock, Deshayes, Rosenqvist , Jeanjean)
- Validation (Woodcock, Strahler, Morisette, Mayaux, representatives from AFRICOVER and other programs, including VEGA2000)

4.4 Carbon Observatory: The overall goal of a Carbon Observatory would be to map current carbon storage as well as changes in terrestrial carbon storage across the global landscape. This is an interdisciplinary effort which is reliant on strong linkages to remote sensing and inventory data. Discussion of the proposed Carbon Observatory resulted in the following:

The meeting representatives reached agreement on development of two current coarse resolution datasets and one future dataset that when validated will act as base layers for the Carbon Observatory. It was further decided that the observatory should move beyond simple classifications of cover types to continuous field information. Specific elements of the coarse resolution dataset to include:

- Coarse Land Cover datasets that will be acquired through Global Land Cover (GLC) 2000 and MODIS to provide a 1 km resolution product up to 4 times per year
- Continuous field datasets will derived to provide enhanced capability for carbon stocks and change detection. Products will

include fractional cover (e.g. % tree cover and green vegetation cover)

- As Global Land Imager (GLI) data become available and are cross validated with MODIS, an additional source of 1km resolution land cover will provide additional change detection capabilities

The proposed Carbon Observatory will support carbon research. The observatory would not be a duplication of the ongoing carbon flux observations that are being conducted but an effort to provide the necessary linkage to land cover change that is intermediate to actual carbon flux. The observatory will account for vegetation cover change, biomass change and density issues (e.g. fractional cover). As envisaged, the observatory will combine, coarse and fine resolution continuous field land cover products. With validation of products, the observatory will assist in testing and verifying a variety of carbon models.

Discussion among the IT members regarding the establishment of Continuous Field datasets (coarse resolution) showed that the community is on track for producing fractional cover products (e.g. % cover, leaf type, leaf longevity, %life form, and %trees). However, it will be necessary to engage the Regional Networks more strongly in the validation efforts. At present there is no validation effort planned although the methodology is already in place. The Observatory Proposal(s) are critical for funding the necessary validation and development activities.

In order for the observatory to function it will be necessary to define community-consensus validation procedures. A Working Group on validation (Strahler, Woodcock, and Morisette) will network with GLC2000 (Mayaux), AFRICOVER and ASIACOVER to achieve consensus on this matter. The Validation Working Group will produce and circulate a goals document which lays out what needs to be done now and a vision what needs to be done in the future. It is anticipated that an additional workshop will be necessary to define the process and implementation approach for achieving the coarse and fine resolution datasets. There should be an agreed upon structure early on in the design phase so as to take into account issues of assigned legends /classes. The Regional Networks will be critical for providing infrastructure and specific datasets (such as Landsat 2000 and Ikonos) to compare and inter-compare existing datasets that will be used to validate both cover and fractional cover. The March GLC2000 meeting will be used as a venue to take up the issue of validation.

The meeting representatives agreed that fine resolution datasets would be necessary for effective detection, monitoring and mapping of changes in carbon stocks. Fine resolution datasets (e.g. Landsat, SPOT) will be nested within coarse resolution datasets at locations where change is known or suspected to be occurring. Special case studies may also make use of fine resolution data to investigate other processes or make linkages to other initiatives (e.g. flux towers).

Fine resolution Land Cover (LC) is a necessary element for the Carbon observatory, especially in areas of rapid change. The goal is to combine remote sensing of land cover and land cover change with information on carbon stock changes, specifically, forest inventory, forest carbon sequestration, and assessment data. Fine resolution data will be used to focus on observable changes. For example, whether changes corresponding to agricultural policy shifts over the last 10-15 years are evident. These efforts will make use of ongoing NASA–GOFC funded activities linking land cover to carbon (e.g. LBA) and other existing Case Studies and Regional Efforts (NASA, GOFC, France, SIBERIA, Tropics (forcing) North America/NACP, EUROPE/CESBIO). Methods for spatially distributed confidence assessments and model-based classification are already under development.

Monitoring of Land Cover Change (LCC) is the next critical element of the observatory once Land Cover (LC) is available. The proof of concept (8km AVHRR km, VGT) for LCC datasets is already in place. The work now needs to be extended to fine resolution data. With proper funding and coordination, the IT expects to be able to provide high resolution LCC maps within two to three years.

Biomass estimation is necessary in order to extend the LC and LCC data to be able to quantify carbon stocks and stock changes. Improved BIOMASS products from Landsat/VGT data for aboveground biomass are possible (preliminary products exist). The utility of SAR data for Biomass estimation, in particular the coherence ERS + JERS data, needs to be established.

A number of special studies/initiatives that will be of importance to the establishment of the Carbon Observatory were identified. Of particular interest are activities to test linkages between remote sensing and forest biomass inventories, and others to test the linkages between remote sensing and tower flux data. It was also considered critical that the IT develop ways to incorporate land USE into the observatory and migrate from emphasis on land COVER to an emphasis on land USE.

- Action: Carbon Working Group to determine how to implement the Carbon Observatory with special attention to linking remote sensing and forest biomass inventories, remote sensing and tower flux data (Schmullius, Cihlar, JeanJean, Defries, Skole, Rosenqvist , Thuy)
- Action: Coordinate the Carbon Observatory activities with UN/IGBP-LUCC activities (Latham and Lambin)
- Action: Prepare a brief on how the proposed global and regional observations of linkages between Carbon, Land Cover and Land Cover Change (C-LC-LCC) can be used to support the requirements of the Kyoto Protocol (Rosenqvist)

The need for future datasets was also recognized. There was considerable interest in identifying and developing special prototype studies to test the fusion

of multi-sensor data and further define the requirements of such systems. Such studies may become elements of the observatory proposal or act as adjunct projects.

It was decided that a Land Cover Working Group (Loveland, Mayeaux, Defries, Latham) is necessary to consider the multifold processing issues and classification schemes. The Working Group will investigate the possible utilization of the FAO Land Cover Classification System (LCCS) and track the LCCS-II e-forum (Loveland and Latham liaisons). This working group will also link with the Validation Working Group to provide continuity.

- Action: Land Cover Working Group to determine the standard approaches to be used in the Carbon Observatory for processing and classification of imagery. Specifically address the utility of using the FAO Land Cover Classification System (LCCS) (Loveland, Mayeaux, Defries, Latham).
- Action: Linkage to provide continuity between the Land Cover and Validations Working Groups (Loveland and Woodcock)
- Action: Tracking of the LCCS-II e-forum with specific attention to the needs of the Carbon Observatory as defined by the Land cover Working Group (Latham and Loveland)
- Action: Provide a GOFC/GOLD representative for the UN/FAO Land Cover topic net meeting (May 2002) (Skole to designate)

Several known issues for implementation of the Carbon Observatory and the requisite datasets were discussed. Classification legends, especially as they relate at different spatial resolutions, are inherently difficult. Coarse resolution pixels are usually mixed compositions of different land covers and therefore the products are inherently inaccurate. Fractional products are an answer to this problem since fractional components resolve the mixed pixel problems and will allow coarse/fine scale classifications to be made coherent. Continuous fields at fine resolution may make use of model-based solutions (e.g. MFM-5 scale). An accepted validation strategy needs to be put in place even though both access and cost (time and money) provide formidable obstacles for validation of the products in many locations/vegetation types.

4.5 Ecosystems Observatory: (for the Millennium Ecosystem Assessment and Other communities) The Ecosystems Observatory will focus on the remote sensing of the extent, integrity, composition and change of the World's various ecosystems. The observatory will use a coarse resolution base map (1-km) that will be progressively overlaid with medium-to-fine resolution remotely sensed data as they become available. Key elements of the discussion about the Ecosystems Observatory follow:

It was agreed that the Land Cover Dataset for the Ecosystems Observatory should be based on medium-to-fine resolution remotely sensed data with a

coarse resolution base layer. Coupling of the coarse and medium resolution data would be used to effectively stratify the global landscape in time and space. Fine resolution data would then be used for spatial assessments of change and coarse or medium resolution data for temporal assessments of change in the sub global assessment regions. By using coarse or medium scale data to detect regions of change it is anticipated that targeted fine resolution data can be effectively collected so as to investigate regions of rapid change.

The Ecosystems Observatory will initially be derived from a compilation of national and or regional land cover maps at medium-to-fine resolution (Landsat, SPOT and SAR). For example, USGS, AFRICOVER, ASIACOVER, Corne LC (Europe), Landsat pathfinder, SIBERIA, SE Asia land cover datasets. The data will subsequently be homogenized to a single geometric projection and a spatial resolution of 100m. The FAO Land Cover Classification System (http://www.lccs-info.org/) will be used to provide a common legend of classes across the observatory dataset. A 1km global land cover map will be used as a background map that will provide continuity and linkage between the higher resolution data regions. GLC 2000 will be used as it becomes available. Global scale coverage is expected by the end of 2003. As part of GLC 2000 working group, GOFC/GOLD is charged with providing guidance on the characteristics the global high resolution Land Cover product. The IT will use this venue to integrate the ongoing GLC2000 efforts with the needs of the Observatory.

Four key variables (land use, land use intensity, landscape fragmentation, composition) to be developed from fine resolution imagery were identified as being key elements of the Ecosystems Observatory. Specifically, land use as inferred from land cover, was considered critical for determining relevant ecosystem impacts and attributes. Similarly, quantifying land use intensity (e.g. how much land is actually being cultivated) is one of the goals of the observatory since it is important for direct quantification of ecosystem impacts and also key for models of the drivers of future land cover and ecosystem change. High resolution data will also be used for quantification of landscape fragmentation and composition (e.g. species composition, crop composition).

Consensus was reached among the participants that the IT should provide guidance from GOFC/GOLD to the Landsat 2000 land cover mapping project regarding land cover derivation. Furthermore, it was agreed that the IT should provide access and distribution for the Landsat 2000 dataset through GOFC/GOLD assets (e.g. regional networks, information systems and centers).

- Action: Provide a letter to NASA (cc: Janetos) that gives the recommendations from the LCCC-IT for guiding Land Cover derivation within the Landsat 2000 mapping project. Furthermore, providing details on how and why the LCCC-IT should provide access to and distribution of the Landsat 2000 product. (Skole to vet with Woodcock and Loveland)

In connection with the observatory the IT has established a 5-year goal to develop a global high resolution land cover dataset. By providing clear standards and methods as well as an ongoing demand for future datasets the IT will use the Ecosystems Observatory to further the case for making the creation of global high resolution land cover datasets more operational in the future. It is critical to have data continuity for the observatory to function, it is believed that by establishing continual demand for these products that the case for continuity in the provision of data (e.g. Landsat) will be reinforced.

A Rapid Land Cover Change dataset will be developed in collaboration with the Millennium Ecosystem Assessment. This will be initiated in tandem with IGBP/IHDP LUCC. GOFC/GOLD will lead and manage the development of a dataset for areas of rapid cover change, while IGBP/IHDP LUCC will manage the interpretation of forces/drivers of change.

- Action: Land Cover Change Working Group that will define the parameters and procedures for identifying, quantifying and monitoring areas of Rapid Land Cover Change with specific emphasis on supporting the proposed Ecosystems Observatory (Defries, Lambin, Skole, Woodcock, Deshayes, Rosenqvist, Jeanjean).
- Action: Coordinate the joint GOFC/GOLD-IGBP/IHDP/LUCC Rapid Land Cover Change dataset development with the Millennium Ecosystem Assessment (Lambin, Skole) through Memoranda of Understanding (Skole)
- Action: Provide the Millennium Ecosystem Assessment with a simple list of available land cover products (Skole, Loveland, Jeanjean)

A number of concerns were raised regarding matters that may affect the success of the observatory. The foremost concern being the long-term availability of data. At present, significant doubts exist regarding the follow on to Landsat. It is felt that without data continuity the observatory will have only limited capability for change detection. As such, the community needs to communicate these needs in a sustained and coordinated fashion to the space agencies (e.g. NASA).

Operational considerations for the observatory that were discussed include the need to obtain better requirements from Millennium Ecosystem Assessment, develop methods for dealing with data on varying qualities (e.g. metadata solutions), temporal issues, definitions of rapid change and the need for field validation of the resultant datasets.

4.6 Forest Status Observatory: GOFC/GOLD is a panel of GTOS charged with providing information on how to create a global system looking at forest characteristics and their changes. The IT needs to provide information to international groups. The Forest Status Observatory will provide a demonstration

of improved global and regional products using new remote sensing technologies by taking advantage of existing research and development activities, for example, data from MODIS sensors and results from VEGA-2000/GLC2000. It will also provide a demonstration of regional high resolution forest/land cover maps including fine resolution fractional cover for degradation assessment (from systems such as Landsat and SPOT). Land cover change and carbon assessments will be included. This observatory was found to be less clearly defined than the Carbon and Ecosystem Observatories and more conceptually difficult in general due to the multiple connections/interactions with local and national entities. Recommendations and concerns included:

Forests are a valuable natural resource for many countries. Forestry issues, together with the potential for carbon accounting under the Clean Development Mechanism of the Kyoto Protocol, has made the monitoring of forests both necessary and problematic. Due to the problems inherent with definitions and negative connotations of frequently used terms in the forestry sector (e.g. management) it was decided that the observatory should be careful and clear in its terminology so as to avoid unnecessary friction with concerned groups.

Successful implementation of the Forest Status Observatory will require a clear, objective and functional observation strategy. To facilitate this team members (Rosenqvist, others) will look at observation strategies and linkages between existing programs/datasets. The goal of the task group will be to have data collected in a systematic manner that is better than it has been done previously and which directly addresses the needs of the observatory. Based on its findings, the task group will make recommendations to CEOS regarding systematic data collection.

- Action: Provide a White Paper on the issue of data acquisition strategies necessary for establishing and implementing the proposed Forest Status Observatory, including the Global Land Imager (GLI) acquisition strategy (Rosenqvist)
- Action: Present the White Paper on data acquisition strategies for the observatories to the Scientific and Technical Board (STB) (Skole, Trencia)

To develop a Forest Status Observatory it will be necessary to clearly define the role of GOFC/GOLD and the IT in the Forestry Area (forest inventory and monitoring). In order to do this effectively it will be necessary for the IT to engage the larger forestry community in this endeavor including international organizations such as FAO and IUFRO, and also engage the national ministries through the Regional Networks. There should be high level correspondence between GOFC/GOLD and the major national and international organizations. The goal should be an open dialogue with the forest community such that they can evaluate the forest maps derived by the observatory in partnership with GOFC/GOLD.

Follow on steps for the observatory include development of a plan for geographic prioritization and the definition of specific operational pilot projects for merging forest inventory and remote sensing data. To facilitate this, IT members (Loveland and Deshayes, Desanker) will evaluate existing datasets, and existing studies that are already using remote sensing.

- Action: Development of a plan for implementing the Forest Status Observatory with specific attention to geographic prioritization and the establishment of pilot projects demonstrating the possibility and utility of merging forest inventory and remote sensing data (Krankina -assist from Trencia and Skole)
- Action: Definition of how to utilize the disparate forest inventory data available at country or regional level in the implementation of the Forest Status Observatory and associated validation issues/approaches (Morisette to Krankina)

Concerns and considerations were raised regarding the observatory and its potential effectiveness. Specifically, it was recognized that it is necessary to integrate with forestry organizations in order to facilitate the process of linking observation, science and management. Furthermore, the observatory needs to be relevant to the users, who will be forest managers. Capacity building and training are to be emphasized in developing countries. Global warming is not 'the issue' for the developing world where concerns with deforestation or logging predominate. A few countries where it is feasible to demonstrate forest monitoring should be selected as initial case studies.

Furthermore, facilitation of the Forest Status Observatory will require sensitivity and clear communications during the implementation process. It will be necessary to provide official letters to forest inventory people (e.g. Russia, Brazil) to let them know exactly what is being done and why. Capacity building, in the form of decision-maker seminars, is necessary to make them aware of the potential of remote sensing, as opposed to training in the technical aspects. The observatory should also link with the Kyoto convention people to determine what indicators they need for monitoring purposes. The IT should also work at making the Forestry community aware of the availability of carbon products.

5.0 Supporting Elements

5.1 Expansion of the Implementation Team and Regional Networks: There was consensus that additional members should be added to the Implementation team. Specific suggestions for new members include a representative from the European Space agency (ESA) and some one from the forestry-remote sensing community (Tuomas Häme). Skole will contact specified individuals and prepare potential nominations. Furthermore, the IT agreed that the Regional Networks should be expanded beyond the current focus regions to better support GOFC/GOLD. Specific regions targeted as needing development of new

Regional Networks include Siberia, China/SE Asia, Central America, and South America.

- Action: Nomination of new IT member nominees (e.g. representatives from ESA, FAO, UNEP and the forestry-remote sensing community (e.g. Tuomas Häme)) (recommendations from IT members)
- Action: Contact of nominated IT members to invite them to join the GOFC/GOLD LCCC-IT (Skole via Secretariat)
- Action: Definition of new Regional Networks, with particular emphasis on identifying lead organizations/personnel. (Land Cover and Land Cover Change Working Groups to make initial suggestions)

5.2 Validation Effort: The validation of existing and planned global and regional forest and land cover products is a high priority that requires a dedicated effort, including the implementation of community-consensus methods. The GOFC/GOLD Regional Networks are a principal vehicle for accomplishing validation. To support a validation effort, a validation workshop focused on developing a validation strategy, identification of sites, and activities for the Regional Networks will be conducted. The initial planning for the Validation Workshop will be conducted at the March 2002, GLC2000 workshop as a side discussion. Mayeux, Strahler/Woodcock, and Cihlar are the task group for this endeavor.

- Action: Planning of a Validation Workshop as part of the Global Land Cover (GLC) 2000 workshop in March 2002 (Mayeux, Strahler/Woodcock, and Cihlar).
- Action: Report plans and action items for the Validation workshop to the IT (Mayeux, Strahler/Woodcock, and Cihlar)
- Action: Validation Working Group to arrange the Validation Workshop and to define community-consesnsus methods that will be used throughout the proposed Carbon, Ecosystems and Forest Status Observatories (Woodcock, Strahler, Morisette, Mayaux, representatives from AFRICOVER and other programs, including VEGA2000)
- Action: Integrate validation strategy with members of the Regional Networks to get their 'buy in' to the process so that the observatories can be made fully operational (Validation Working Group)

5.3 Land Cover Characteristics and Changes Implementation Team Web Site: A central website for the Land Cover Characteristics and Changes Implementation Team will be developed. Michigan State University (MSU) will take the initial lead in hosting and developing the site. The Meeting Report and individual presentations by the participants of the February 11-13 Toulouse,

France workshop will be some of the initial materials included (http://bsrsi.msu.edu/gofc-gold/toulouse/).

- Action: Establish Land Cover Characteristics and Changes Implementation Team website, including general information about the IT, projects and products (Cochrane and Skole)
- Action: Post the LCCC-IT Meeting Report and presentations made by contributors at the meeting on the website (Cochrane and Skole)
- Action: Integrate links to IT activities and products on the website (Cochrane)
- Action: Interlink website with the GOFC website (Cochrane and Secretariat)

5.4 Workshops and Conferences:

5.4.1 Workshop on Remote Sensing in Inventory and Monitoring of Boreal Forests in Europe. This workshop will focus on the integration of satellite derived data with ground based inventory data so that limited inventory data can be appropriately applied to regional forests and so that remotely sensed data on forest cover can be enhanced with estimations of other forest parameters. These information will directly contribute to the proposed observatories for Carbon, Ecosystems, and Forest Status. The workshop will provide the official start of the North-European Regional Information Network (NERIN) that will focus on Finland, Norway, western Russia, and Sweden. The workshop will be held in Hanasaari, Espoo, Finland in September 2002 and will be coordinated by Tuomas Häme and Olga Krankina.

5.4.2 Workshop on Linking Remote Sensing of Land Cover Change and Carbon Flux Data. This workshop will explore the possibility of integrating satellite derived information of changes in land cover with atmospheric information on carbon flux, for example, flux tower data. The goal is to help provide the land cover context for the flux data so that these data can be properly interpreted and thereby allow for landscape level extrapolation based on remotely sensed measures of land cover change. This workshop will be coordinated by Steve Running and David Skole in July 2002.

5.4.3 GOFC/GOLD Conference 2003 The Implementation Team determined that a GOFC/GOLD wide conference to showcase the activities, accomplishments and overall goals of the GOFC/GOLD effort is needed and should be arranged for 2003. The results of the conference will be used to further the GOFC/GOLD agenda through the development of a book or suite of state of the art papers that will be disseminated to the larger community of interested groups (international organizations, national and state governments, relevant agencies, research groups etc). The location and exact time frame for the conference have yet to be

determined.

5.5 Additional Directed Activities: The meeting participants determined that the Land Cover Characteristics and Change Implementation Team needs to have a Secretariat to assist in the coordination of the IT activities, especially as they pertain to the proposed observatories. Therefore, Skole will head up an effort to establish an IT secretariat, with a network coordinator, and general support to regional networks.

The work of GOFC/GOLD Land Cover Characteristics and Change Implementation Team, and the proposed Carbon, Ecosystems and Forest Status Observatories in particular are cross-cutting with other programs. Therefore it will be necessary to maintain close liaisons with the carbon cycle and land cover communities as well as pertinent international organizations. Specific needed liaisons include:

- Action: Establish a Secretariat for the LCCC-IT that is capable of coordinating the IT activities for developing, funding, promoting and implementing the proposed Carbon, Ecosystems and Forest Status Observatories (Skole)
- Action: Liaison to the GTOS Terrestrial Carbon Observation (TCO) (Cihlar)
- Action: Liaison to the International Geosphere-Biosphere Programme (IGBP) (TBD)
- Action: Liaison to the Land-Use and Cover Change (IGBP-IHDP/LUCC) (Lambin)
- Action: Liaison to the United Nations Environmental Programme (UNEP) – TBD (communication, Skole to Fernandez)
- Action: Liaison to the Food and Agriculture Organization (FAO) AFRICOVER Project – TBD (communication, Skole to Latham)

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