The Toulouse Plan: Implementation of the Land Cover Characteristics and Changes Implementation Team.

Toulouse, France

11 - 13 February 2002

Skole, D.

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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

The Toulouse Plan
Implementation of the Land Cover Characteristics and Changes Implementation Team

Based on the Report of the IT Meeting
11-13 February 2002
Toulouse, France

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

1.0 Introduction

This Plan is based on the report from the Toulouse workshop in 2002. We have updated the Plan with a current assessment of the status of the actions proposed by the IT over the past year. Each section has a suite of proposed actions. We provide the updated status to each of these written in red font.

We also include a section at the end on current activities, some of them are cross-cutting to many actions, some arising as new starts after the workshop.

2.0 Actions and Recommendations

2.1 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 tracking changes in these characteristics over time. It is critical to have series of directly comparable observations in order to accomplish these tasks. The Implementation Team intends to establish observatories that are capable of assuring continuous data acquisition and processing that is of sufficient quantity and quality for global and regional evaluations of land cover characteristics. These observatories are not conceived of as physical objects or locations but instead as conceptual guidelines that provide specification of overall data acquisition strategies, necessary data sources, classification schemes, quality, and validation components necessary 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 remotely sensing the extent, integrity, composition and changes 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 and fine resolution fractional cover for forest degradation assessments.

2.2 Implementation Plan for the Observatories: The conceptual outline of the Carbon, Ecosystem and Forest Status Observatories, together with detailed descriptions of how to implement and operationalize each observatory, will be

formed as a research proposal. The document will 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. The overall funding strategy for the observatories will 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.

2.3 Working Groups to Support the Observatories: Four specific focus areas for continued discussion regarding the development of the Observatories 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, Le Toan)
- Land Cover (classification schemes and processing issues) (Loveland, Mayaux, 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)

2.4 Carbon Observatory: The Carbon Observatory will map current carbon stocks and changes in terrestrial carbon storage across the global landscape. This interdisciplinary effort relies on strong linkages between remote sensing and inventory data. There are several known issues that will need to be addressed

including classification schemes, spatial resolution and the need for continuous field data. 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 these products are inherently inaccurate. Fractional products are an answer to this problem since fractional components resolve the mixed pixel issue and enable construction of coherent coarse/fine scale classifications. At fine resolution, continuous fields can make use of model-based solutions (e.g. MFM-5 scale) for enhancement. Validation will be key to making the Carbon Observatory operational and must be emphasized throughout the development and funding process even though both access and cost (time and money) provide formidable obstacles for validation of the products in many locations/vegetation types.

Two current coarse-resolution datasets and one future dataset, once validated, will act as base layers for the Carbon Observatory. The observatory will move beyond simple land cover classifications to incorporate continuous field information. The coarse-resolution dataset will 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
- Derived continuous field datasets to provide enhanced carbon stock estimation and change detection. Products will include fractional cover (e.g. % tree cover and green vegetation cover)
- Global Land Imager (GLI) data will be used as an additional source of 1km resolution land cover will provide additional change detection capabilities once it has been cross-validated with MODIS

The Carbon Observatory will support ongoing and future carbon research. The observatory will not duplicate ongoing carbon flux observations but will 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. Product validation will enable testing and verification of a variety of carbon models.

IT members and other scientists are currently developing the necessary methodologies and processing capabilities for continuous field datasets (coarse resolution) including fractional cover products (e.g. % cover, leaf type, leaf longevity, %life form, and %trees). Validation of the continuous field products will require strong engagement of the Regional Networks and these activities must be built into the observatory proposal. No validation efforts are planned under currently funded projects although the methodology is already in place. The Observatory Proposal(s) are critical for acquiring the funding necessary to support the validation and development activities that are central to carrying out the IT's GOFC/GOLD charges.

For the observatory to function it is 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 that 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 required coarse and fine resolution datasets. The structure will be agreed upon early on in the design phase so as to take into account issues of assigned legends /classes. The Regional Networks will provide infrastructure and specific datasets (such as Landsat 2000 and Ikonos) to compare and inter-compare existing datasets to validate land cover classifications and fractional cover products. The March GLC2000 meeting will be used as a venue to take up the issue of validation.

Fine resolution datasets are required 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 will make use of fine resolution data to investigate other processes or make linkages to other initiatives (e.g. flux towers).

To effectively monitor changes in carbon stocks, the Carbon Observatory requires fine resolution Land Cover (LC) products, especially in areas of rapid change. The observatory will combine remote sensing of land cover and land cover change with field information on carbon stock changes, specifically, forest inventory, forest carbon sequestration, and assessment data. Fine resolution data will be used to verify and quantify observed or suspected changes in land cover class or characteristics. For example, observatory data could be used to determine whether agricultural policy shifts over the last 10-15 years are evident within the imagery. 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.

Once Land Cover (LC) is available, monitoring of Land Cover Change (LCC) is the next critical element of the observatory. The proof of concept (8km AVHRR km, VGT) for LCC datasets is already in place. The LCC monitoring capabilities now need 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.

To quantify carbon stocks and stock changes it is necessary to extend the LC and LCC data with biomass estimations. Improved aboveground BIOMASS

estimation products, derived from Landsat/VGT data, are possible and preliminary products exist. The utility of SAR data for biomass estimation, in particular the coherence ERS + JERS data, needs to be established through extensive calibration/validation.

A number of special studies/initiatives will be important for establishment of the Carbon Observatory. Of particular interest are activities that test linkages between remote sensing and forest biomass inventories, and others that test the linkages between remote sensing and tower flux data. The IT will take a lead in developing methodologies for incorporating and emphasizing land use into observatory products and migrate away from reliance on discrete land cover classifications.

2.4.1 Actions Proposed and Their Status

- 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 , Le Toan)

Le Toan reports the status:
During the period from February 2002 to February 2003, our on going research activities to support Carbon Observatory can be summarised as follows:

1. Developing the necessary methodologies for using the forthcoming ALOS (Advanced Land Observation Satellite). The objective is to use spatially and temporally consistent ALOS data-sets whose acquisition is already defined in the NASDA Kyoto-Carbon Initiative (A. rosenqvist) to map forest cover and to monitor biomass of post disturbances areas (e.g. biomass in the range of 0-50 tonnes/ha) in the major forest biomes. The goal is to support the information requirements for forest and land use changes posed by UNFCC Kyoto Protocol.

2. Studying the combination of remote sensing of biomass and dynamic vegetation modelling in order to identify carbon sources and sinks in forests after disturbances, and their variation with time.
   (*Le Toan, T., S. Quegan, I. Woodward, M. Lomas and N. Delbart: "Radar remote sensing of biomass combined with dynamic Vegetation Modelling to assess carbon budgets of forests",*
   Submitted to Journal of Climatic Change, March 2003
   The study was based on biomass mapping using simulated L band polarimetric SAR data, combined with the Dynamic Vegetation Modelling. Simulation results suggest that during the first 10 years or more after disturbances, forests can be carbon sources)

3. Co-ordinating Earth Observation activities in the SIBERIA-II project. The objective of SIBERIA-II is to provide Carbon and Greenhouse Gas accounting for Northern

Eurasia (C. Schmullius). Earth Observation topics under study in the first phase include: examination of information requirements in accounting and modelling methods, and examination of candidate EO data in terms of a) their availability, b) their information content with repect to the required information, c) their spatial and temporal resolution, d) availability of the geophysical products and/or e) feasibility and availability of retrieval algorithms. The selected sensors/data are: MODIS (land cover, fAPAR, phenology), ENVISAT ASAR (biomass, wetland), Quikscat (freeze/thaw) and SSM/I (snow).

- Action: Coordinate the Carbon Observatory activities with UN/IGBP-LUCC activities (Latham and Lambin)
- Action: Prepare a brief on how linking global and regional observations of Carbon, Land Cover and Land Cover Change (C-LC-LCC) can be used to support the requirements of the Kyoto Protocol (Rosenqvist)

The Carbon Observatory will also require the development of future datasets. Special prototype studies testing the fusion of multi-sensor data, or further defining the requirements of such systems, will be valuable. These studies can become elements of the observatory proposal or act as adjunct projects.

A Land Cover Working Group (Loveland, Mayaux, Defries, Latham) will consider the multifold processing issues and classification schemes required by the observatory. The Working Group will investigate 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 standard imagery processing and classification approaches for the Carbon Observatory. Evaluate the utility of using the FAO Land Cover Classification System (LCCS) (Loveland, Mayaux, 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) – Delete ?

3.5 Ecosystems Observatory: The Ecosystems Observatory will focus on remote sensing of the extent, integrity, composition and change of the World's various ecosystems and provide detailed information for the Millennium Ecosystem Assessment and other communities. 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.

The Land Cover Dataset for the Ecosystems Observatory will be based on medium-to-fine resolution remotely sensed data with a coarse resolution base layer. Coupling of the coarse and medium resolution data will effectively stratify the global landscape in time and space. Using coarse or medium scale data to detect regions of change will enable targeted fine resolution data acquisition to investigate regions of rapid change. Frequently collected/processed coarse-medium resolution data will be used for temporal assessments of change. Fine resolution data will be used for less frequent spatial assessments of change.

The Ecosystems Observatory will be initiated through the compilation of several existing national and 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. These data will 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 provide a common legend of classes for the observatory dataset. A 1km global land cover map will be used as a background map to provide continuity and linkage between the higher resolution data regions. As part of the 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. GLC 2000 data will be used as it becomes available. Global-scale coverage is expected by the end of 2003.

Four key variables (land use, land use intensity, landscape fragmentation, composition) derived from fine resolution imagery will be important elements of the Ecosystems Observatory. Specifically, land use as inferred from land cover, is critical for determining relevant ecosystem impacts and attributes. Similarly, quantifying land use intensity (e.g. how much land is actually being cultivated) is needed for direct quantification of ecosystem impacts and also as input for modeling of the drivers of future land cover and ecosystem change. Fine resolution data will also be used for quantification of landscape fragmentation and composition (e.g. species composition, crop composition).

In support of the Ecosystems Observatory, the IT will guide the land cover derivation activities of the Landsat 2000 land cover mapping project and also use GOFC/GOLD assets (e.g. regional networks, information systems and centers) to provide access and distribution for the Landsat 2000 dataset.

- Action: Provide a letter to NASA (cc: Janetos) with the LCCC-IT recommendations for Land Cover derivation within the Landsat 2000 mapping project, complete with 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)

As part of the Ecosystems Observatory, the IT has a 5-year goal for developing a global high resolution land cover dataset. In the process, the IT will provide clear standards and methods for data collection, processing, validation and distribution. Of prime concern for the viability of the observatory is the long-term availability of comparable satellite data. At present, significant doubts exist regarding future availability of Landsat data after Landsat 7. 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). In making heavy use of satellite imagery for its baseline and continuing product derivations, the observatory will reinforce the case being made to ensure the future continuity of imagery data (e.g. Landsat) that is available to the science community.

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 the dataset for areas of rapid cover change, while IGBP/IHDP LUCC will manage the interpretation of forces/drivers of change. Operational considerations for the observatory include, better-defined requirements from Millennium Ecosystem Assessment, methods for dealing with data of varying qualities (e.g. metadata solutions), temporal issues, definitions of rapid change and field validation of the resultant datasets.

- 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)

3.6 Forest Status Observatory: GOFC/GOLD is a panel of GTOS charged with providing information on how to create a global system for looking at forest characteristics and their changes. The IT views establishment of a Forest Status

Observatory as the most efficient way of accomplishing this goal. The Forest Status Observatory will demonstrate improved global and regional products derived by synthesizing existing research and development activities together with new remote sensing technologies. For example, data from MODIS sensors and results from VEGA-2000/GLC2000 will provide the necessary input data for regional analyses of forest condition. Demonstration of regional, high-resolution forest/land cover maps, including fine-resolution fractional cover for degradation assessment, will be done using systems such as Landsat and SPOT. In addition to spatial characterization of forest status, land cover change and carbon assessments will be included in the observatory's suite of products.

This Forest status Observatory is conceptually more difficult than the Carbon and Ecosystem Observatories due to the necessity for multiple connections and interactions with local and national entities. 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, have made the monitoring of forests both necessary and problematic. The observatory will link with appropriate personnel involved in the Kyoto convention to determine what indicators are required for carbon monitoring purposes. The IT will ensure that the larger Forestry community is made aware of the availability of the observatory's carbon products.

In the developing world, concerns about deforestation and logging predominate over global climate change issues among forest managers. The interaction and potential synergy among different land uses and cover types can dramatically impact forest condition and affect management decisions but only if these complex interactions can be clearly shown and spatially articulated. To link observation, science and management and enhance the potential effectiveness of the observatory, it will be necessary to integrate forestry organizations into the observatory development process. This is a critical element for making the Forest Status Observatory relevant to its end users, who will be forest managers. Capacity building and training are to be emphasized, especially in developing countries. The capacity building needs to transcend training in the technical aspects of the observatory to provide decision-maker seminars that can make them aware of the potential of remote sensing and the derived products in forestry applications.

Facilitation of the Forest Status Observatory will require sensitivity and clear communications during the implementation process. Specifically, 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. Due to the problems inherent with definitions and negative connotations of frequently used terms in the forestry sector (e.g. management) the observatory needs to be careful and clear in its terminology so as to avoid unnecessary friction with concerned groups. A few countries, where it is feasible to demonstrate the capabilities of the

Forest Status Observatory for forest monitoring, will be selected as initial case studies.

Successful implementation of the Forest Status Observatory requires a clear, objective and functional observation strategy. To facilitate this team members (Rosenqvist, others) will investigate observation strategies and linkages between existing programs/datasets. The goal of the task group is to define a systematic method of data collection that directly addresses the needs of the observatory and is better than what has previously been accomplished. Based on its findings, the task group will make recommendations to CEOS regarding data needs for the observatory.

- 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)

Development of the Forest Status Observatory requires the role of GOFC/GOLD and the IT to be clearly defined and related to the larger Forestry Community. This will be accomplished by including international organizations, such as FAO and IUFRO, in the process and by engaging national ministries, through the Regional Networks, so that they will 'buy in' to the objectives and results of the Forest Status Observatory. High level correspondence between GOFC/GOLD and the major national and international organizations will be maintained throughout the establishment process for the observatory. The goal is to create an open dialogue with the forest community wherein they can evaluate and contribute to the forest maps derived by the observatory in partnership with GOFC/GOLD.

The proximate steps for planning development of the Forest Status Observatory include geographic prioritization and 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 ongoing studies that are already using remote sensing to assess forest status and evaluate their applicability to the Forest Status Observatory..

- Action: Development of an implementation plan for 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)

4.0 Potential Contributory Projects

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

Synopses of several potential contributory projects are provided. These projects will be key components of the proposed monitoring strategy for carbon, ecosystems and forest status. In addition, the presentations that were made at the Land Cover and Characteristics Change Implementation Team meeting are available for viewing on the following website (http://www.globalchange.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 that 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) provides 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) USGS Land Cover Projects include 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, 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 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) Multi-resolution change detection, using coarse-resolution percentage tree cover estimates handles the challenges inherent in measuring and monitoring continuous field representations of forest cover characteristics by making repeated observations at both coarse and fine resolution. Automated analysis of coarse resolution data identifies major, broad-scale characteristics and changes in forest cover allowing targeted use of fine resolution imagery for making detailed analyses of land cover change. By combining coarse and fine resolution data, forest cover change can be monitored effectively. MODIS data, in particular, has a strong potential for estimating percentage tree cover frequently across wide regions. 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 acquire temporally and spatially homogeneous coverages of JERS-1 SAR data to provide “snap shots” of the state of tropical and boreal forests. These 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 data fusion from 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. SIBERIA-II makes use of data from 12 different satellites in a multi-sensor (multi-temporal, multi-spatial) data fusion. 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 is done using high resolution (Landsat) imagery and a generalized automated change detection technique (Fuzzy ARTMAP). Accuracies of the technique match conventional methods. Generalization methods allow 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 conduct 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) This 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. Originally run by a consortium of universities and research centers, ENAMORS conducts Earth Observation using space-based remote sensing techniques in the optical domain. ENAMORS promotes 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. LCCS (Land Cover Classification System) is a new concept of land cover classification

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 UNEP and IGBP. LCCS is being used by several international organizations (e.g. JRC for GLC2000) and many countries. The whole methodological approach and related software form the AFRICOVER "thematic package". These software and information are 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 global extent of various ecosystem types in the year 2000. Land cover types will 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.

EOSD Land Cover: (Dr. Wulder, Canadian Forest Service). Earth Observation for Sustainable Development of Forests (EOSD) land cover is a joint Canadian Forest Service and Canadian Space Agency project working in collaboration with provinces and territories to map the land cover of the forested areas of Canada using circa 2000 Landsat images. The EOSD land cover legend is a full vegetation resources inventory that is compatible with the National Forest Inventory (NFI) legend and contains 20 classes of land cover. Implementation has begun and will consist of classifying new imagery as well as translating existing provincial land cover legends to the NFI/EOSD legend. The target date for the completion of the 2000 land cover of forested areas of Canada is 2005/06.

5.0 Supporting Elements

5.1 <u>Expansion of the Implementation Team and Regional Networks</u>: There was consensus that, to increase its effectiveness, additional members need to be added to the Implementation Team. Specific suggestions for new members include representatives from the European Space agency (ESA) and some one from the forestry-remote sensing community. 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 for development of new Regional Networks include Siberia, China/SE Asia, Central America, and South America.

- Action: Nomination of new IT members (e.g. representatives from ESA, FAO, UNEP and the forestry-remote sensing community (e.g. Tuomas Häme) (recommendations from IT members)
- Action: Invitations to join the GOFC/GOLD LCCC-IT extended to nominated IT members (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 definition and 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. Mayaux, 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 (Mayaux, Strahler/Woodcock, and Cihlar).
- Action: Report plans and action items for the Validation workshop to the IT (Mayaux, Strahler/Woodcock, and Cihlar)
- Action: Validation Working Group to arrange the Validation Workshop and to define community-consensus 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://www.globalchange.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 – New Date?.

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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