GOFC-GOLD GLOBAL OBSERVATION OF FOREST AND LAND COVER DYNAMICS

Report of the Forest Cover Implementation Team. GOFC Science and Technical Board Meeting

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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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1.0 MEMBERSHIP OF THE IMPLEMENTATION TEAM

The Forest Cover Characteristics and Changes Implementation Team (FC-IT) now includes the following members.

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New members are being sought from Canada and the JRC in Europe. These additional names are being sought to bring into the team members from the Canadian remote sensing and/or forestry communities and someone from the Global Land Cover 2000 project. In addition we have an agreement to include Mr. Paul Reichert from the FAO to build coordination with the AsiaCover and AfriCover projects. Lastly we are hoping to invite Dr. Thelma Krug from the Brazilian space agency, INPE. Additional members will be added as necessary.

2.0 NEAR TERM FOCUS FOR THE WORK OF THE FC-IT

2.1 Initial Priorities, Forest Cover IT

2.1.1. Forest cover and carbon

– Contribute to the development of a global carbon observatory for carbon source-sink issues, both in a scientific and policy context.

a) characterization of the missing sink in temperate zone forests, as a function of changes within forests through changes in density, changes in the extent of forest areas, replacement of other systems by forests, or loss of forests,

b) source terms in the tropics, the uncertainty leading directly to uncertainty in the estimated sink,

c) issues of measurement methods for large area assessments of changes in land covers into and out of forest classes, changes in stand density, and methods for linking in-situ measurements from stand inventory data to remote sensing data.

- In terms of policy there is a clear need to investigate methods for measuring forest changes in such contexts as Kyoto protocol. The focus would be on prototyping acquisition, some initial products, validation assessment and methods testing/development.

2.1.2. Ecosystem Assessment

– To provide a demonstration of the role for global observational data for other international needs beyond carbon,

- GOFC should support product needs for the Millennium Ecosystem Assessment with a focus on information relevant to biodiversity and ecosystem structure and distribution.

2.1.3. Forest resource assessment and management.

- Using the regional networks the IT will target key projects for demonstration of support to forest managers and the national scale.

- Emphasis is not on capacity building but to seek input from the forestry agencies and prototype some key outputs and products, which make use of new remote sensing information coupled to in-situ measurements.

- This will also assist in the development of regional "harmonized" forest inventories (as maps) merged from individual country efforts.

2.2 Early Initiatives

2.2.1 Improve access to remote sensing data

- Develop a global data set of coarse and fine resolution data (such as global Landsat data for 2000) and make them available through a GOFC mechanism to users, such as FAO, who need access to imagery. This will be done through CEOS agency contributions, data buys, other mechanisms. The goal will be much improved data and information system for widespread dissemination of data sets.

2.2.2 Improved pre-processing of remotely sensed data.

- Develop a prototyping effort for improved products through "best-practices" or community consensus atmospheric correction, and georegistration. Assess the potential for improved system correction and evaluation of existing methods.

2.2.3 Evaluation and validation of global land cover products.

- Validating global and regional land cover products is a very high priority. The principal vehicle for doing this will be regional GOFC networks for validation.

2.2.4 Improved global land cover products

- Provide a demonstration of improved global land cover products using new remote sensing technologies taking advantage of existing research and development activities. sensors, e.g., from MODIS and results from VEGA-2000/GLC2000. Also demonstration of regional high resolution forest/land cover maps including fine resolution fractional cover for degradation assessment (from systems such as Landsat and Spot)

2.2.5 Land cover change monitoring

- Demonstration of a multi-level Land Cover Change monitoring systems - global moderate resolution change detection with responsive high-resolution acquisition and associated distribution system. Coordinating a state-of-the-art-review of methods for global assessment of deforestation will also be a goal.

2.2.6 Coupled remote sensing in situ systems

– Demonstration of coupled remote sensing-in situ approaches, such as the kNN technique and others, which are being developed within the forest management community.

2.2.7 Regional carbon data bundles

- Integrated sets of data (or bundle) relevant to regional carbon assessment including forest type, fractional cover, area of change and biomass inventory will be created and made available

3.0 EXAMPLES OF CONTRIBUTORY PROJECTS

There are several important contributory projects on-going or soon to be initiated which could be part of the activities of the team. These include, as examples: Global Land Cover 2000 project of the JRC, the VEGA 2000 project of CNES, NASA's several activities of the MODIS Land Team and the Landsat 7 mission (including the Landsat Data Continuity Mission), several university projects including the University of Maryland's Percent Tree Cover and Michigan State University's Tropical Forest Inventory, FAOs AfriCover and its new AsiaCover, several national deforestation and forest inventory efforts in Canada, Brazil, and Southeast Asia, the efforts of the Southeast Asia Regional Information Network.

There are also new opportunities to cooperate with the Millennium Ecosystem Assessment program and the carbon cycle initiatives in the US, Europe and internationally through the IGBP. These latter efforts need to be tied closely with the TCO initiatives within GTOS.

4.0 ACTIVITIES

The FC-IT has been active in establishing requirements and setting regional infrastructure.

4.1 Requirements and product definition.

The FC-IT has developed a draft specifications document for product generation, which is attached as Appendix 1 of this report.

4.2 Planning workshops and development of regional networks.

These include:

- *Atelier de création du réseau GOFC - OSFAC en Afrique CentraleLibreville, Gabon, February 22-24, 2000*

- *Southeast Asia Regional GOFC Planning Meeting at Bogor, Indonesia, January 31 – February 2, 2000*

Reports of these workshops are on the GOFC web site. A new workshop is being planned for the Russia and Fennoscandia region:

- *GOFC Regional Workshop on Remote Sensing of Forest Cover in NorthwesternRussia and Fennoscandia, June 25-27, 2001 - hosted by INENCO Center of RAS*

The goal of this regional GOFC workshop is to promote a coordinated effort among scientists in the region towards building an observational boreal forest network which would result in operational monitoring of forest cover and forest cover change, and to make data and information on forests usable and accessible. The workshop will examine current uses of remote sensing in studies of forest cover and carbon exchange in the region, evaluate existing data sets useful for validation and interpretation of remote sensing data products, identify future needs of different user groups, and plan future interdisciplinary research and exchange activities. The workshop will also discuss forest inventory, monitoring, management, and conservation. They will explore current gaps of knowledge in land use and the carbon budget for the region, including understanding of changing disturbance regimes and driving forces of land use change. Location: St. Petersburg, Russia Contact: Olga Krankina, Oregon State University

4.3 Other activities, including funding

The team has installed a GOFC Fellowship at Michigan State University. Mr. Chetpong Butthep from the Thai space agency is in place for one year to help coordinate the efforts of the IT with the SE Asia regional network.

A proposal to the Asia Pacific Network was submitted this year as was funded for US$ 80K for the first year. This project will help coordinate the product development for the SE Asia network, including field calibration and validation. A summary of this project is attached as Appendix 2 and 3.

The IT has been working with the CEOS WGISS to develop information systems and services for access to data and information. Please see initial project results on the GOFC web site under Data pages.

5.0 NEEDS FROM THE STB

The IT will need considerable support from the STB including access to large datasets, and assistance in securing funding for the operation of the IT activities. This includes support of the IT itself and its activities and the regional networks. In the next year we envision support needed primarily for workshops and meetings of the IT. In addition we will need to support:

- Development of global products using VEGA 2000 and MODIS results, including the validation efforts

- Transitioning research on forest fractional cover to operational use, possibly several pilot studies

- Development of forest change techniques including workshops for inter-comparison of methods and harmonization between various national efforts

- Development of an initial start of a Forest Cover Information System

- Participation in the activities of three potential cooperating programs: the FAO programs on AsiaCover and AfriCover, The Millennium Ecosystem Assessment, and the international and national carbon cycle initiatives

6.0 STB MEETING

More detailed information will be forthcoming at the STB meeting itself

APPENDIX 1

SUMMARY OF PRODUCTS

Forest Cover Characteristics and Changes Implementation Team

1 June 2001

Background document for the GOFC Science and Technical Board1.0

1.0 INTRODUCTION

This document provides *DRAFT* definitions and specifications for a products suite to be developed by the GOFC Forest Cover Changes and Characteristics Implementation Team (FC-IT). The product suite is aimed at both global and regional/national scales, and is focused on information needs for the *Initial Priorities* and *Early Initiatives* of the FC-IT to support three thematic foci and users:

1) global change research community with an emphasis on the global carbon cycle,

2) international policy and assessments, with a proposed emphasis on the Millennium Ecosystem Assessment, and

3) national and regional forest management users.

This document is a general overview. It is meant to layout the important technical implementation issues, regardless of who or what organization implements the products. Moreover, it is not a final specification document. This product suite is preliminary and will be refined over the course of the next 6-12 months by the FC-IT. It is based on the GOFC design strategy and precursor efforts of the Coarse and Fine Resolution Design Teams. Full reports from these design teams can be found on the GOFC web site.

2.0 GENERAL CONSIDERATIONS

Recommended for the development of the FC-IT product suite are based on some fundamental considerations, such as:

- Products developed should be achievable, whenever possible, with current technology (i.e., using data from sensors either currently operational, or scheduled to be operating in the coming year). The approach, however, should also include definitions of optimal characteristics that may be achievable with advancements in future remote sensing systems.

- On-going product development must be practical and lead to a reasonable operational concept, implemented using existing and near-term observational systems, with a straightforward and management level of effort.

- Products should be developed using existing and near term programs, and should include proven or near-ready applications rather than new experimental approaches which require considerable research and development.

- However, research will be a necessary component in most product development strategies and will be important for the long-term development of new products; as such it should be an integral element of the work of the FC-IT.

- Product definitions and specifications should be periodically reviewed and improved so that advances in methods and source data characteristics can be incorporated to improve overall data quality.

- Validation of data products is necessary to evaluate product quality, and also to identify new research priorities.

3.0 PRODUCT LEVELS AND SUITES

A review of the individual requirements of global change, forest inventory, and policy communities reveals a striking convergence, or similarity in scope and definition. The most complex and stringent requirements are set by the forest inventory users since they have needs for detailed forest cover characteristics linked to specific in-situ data with high spatial accuracy and precision. The carbon cycle community and policy users (particularly the emissions inventory requirements) have of subset of these needs. Thus, it is possible to define a single common data bundle, which satisfies a very broad range of users and at the same time focuses on the requirements for the global carbon community, forest inventory community, and the policy community.

This FC-IT will focus on development of a suite of datasets and data products with the following general hierarchy levels:

> ***Level 1****:* raw fine and coarse resolution data such as ETM+, Spot, MODIS or any other which are not atmospherically corrected and georeferenced by system correction only.
>
> ***Level 2***: Enhanced image datasets, which will include fine and coarse resolution image data from TM, ETM+, ALI, MODIS and VEGATATION which have been atmospherically corrected, georeferenced to earth coordinates, projected, normalized for view / sun angle effect, and mosaicked when multiple scenes needed will also be provided.
>
> ***Level 3****:* Derived data products, which will include the results of analyses of image products. These products will be used to improve existing global land cover maps of forest density, assessments of deforestation, and other information on forest cover characteristics and changes.

We believe that some users will primarily need access to the Level 1 and Level 2 datasets, such as the UN FAO Forest Resource Assessment program which routinely acquires the image data and performs its own in-house data analysis. Others, such as the forest inventory community need access to Level 3 derived data such as extant forest density and fractional cover for making forest inventory or deforestation and forest degradation assessments

4.0 SPATIAL COVERAGE

In order to design a monitoring system capable of monitoring both high and low frequency changes in forest, we propose to establish across spatial and temporal resolution system, using data from multiple satellite and in-situ data sources. It consists of a data system at three temporal and spatial scales.

> ***Global****:* This coverage will focus on datasets and products with global coverage, and will rely heavily on the coarse resolution datasets. Regional subsets or regional components can be used to assemble a global product, but priority will be given to single global datasets. These will be developed mostly for Forest Cover products.
>
> ***National and Regional*** : This scale is developed and employed for National Forest Inventory assessments and monitoring and other regional and national uses. These products will be developed mostly from fine resolution source data, while some regional products with regionally-specific classifications may also appear. These datasets will be most useful for change analysis.
>
> ***Focus Areas and Sites***: These focus areas serve two purposes: (1) calibration and validation of derived products, and (2) evaluation and testing of products for forest management applications.

5.0 PROCESSING

Imagery acquired must be processed so the data can be analyzed quantitatively. This includes five processing steps that are detailed in the following sections.

5.1 Georeferencing.

Images will be georeferenced to a common coordinate system. To geo-reference the 30m resolution imagery and its derived products, one method might be to use ortho-rectified historical TM imagery acquired through the NASA Science Data Buy program at Stennis Space Center. The product produced for NASA by EarthSat will be a georeferenced TM data ± 60m of its true coordinates. Problems of relief are greatly reduced in this dataset. The mosaicked images can be used to serve as a template for georeferencing all other 30m resolution satellite images to be acquired. It must be noted that the Landsat program is producing very good locational accuracy with system corrected algorithms using the post-pass ephemeris.

For 250m - 1km resolution imagery and derived products, we could use the VEGETATION imagery from SPOT 4 satellite as a template. Unlike the AVHRR, VEGETATION sensor has a spatial resolution of 1.1km across the entire scene. Because the sensor uses an array of detectors, each having its own instantaneous field of view, the spatial resolution across the entire image is approximately the same. The spatial accuracy of this sensor is ?500m. Alternatively, MODIS 250 data could be used. Another alternative, but with more effort, fine resolution data could be used from the method above.

5.2 Atmospheric Corrections

Atmosphere affects optical remote sensing signals two ways. It attenuates the solar radiation reaching to the earth surface and that reflected off the earth surface to the satellite sensors. As a consequence, the signal arriving at the sensor will be weakened and the resulting image will be darker. On the other hand, the atmosphere scatters solar radiation in all directions, including the direction where satellite sensors are viewing, thus contributing significant scattered radiation toward the sensor. The result of the atmospheric contribution, often termed as path radiance, is to increase the brightness of the image, and to reduce the contrast of the earth surface features. Therefore, the atmospheric effect in satellite images must be accounted for. There are several methods that can be used to correct such effects. Sophisticated methods require precise measurements of atmospheric properties such as water vapor content and aerosol density. In tropical regions, both aerosol and water vapor content varies spatially and temporally and, therefore, deployment of instruments for atmospheric measurements appears impractical. Another way to characterize the atmospheric properties is to model the atmosphere as a layered medium, which exerts effects on incoming and reflected solar radiation (Kaufman 1989). The physical properties of the atmosphere can be modeled as a function of latitude, longitude, and day of year. The modeling approach often takes substantial computation time, and thus correction of atmospheric effects on large-scale satellite images often prevent operational uses of satellite imagery. A simplified method exists (Rahman and Dedieu, 1994) and is being used to in some labs to operationally correct the VEGETATION data. Therefore, we proposed to use the simplified method based on Rahman and Dedieu (1994) to correct satellite images.

Three practical methods have potential to use in this investigation for atmospheric correction. The first is to take advantages of already-corrected VEGETATION data. By comparing the statistical means of a large area common on both the atmospherically corrected VEGETATION image and the image to be corrected for each corresponding spectral band, an adjustment can thus be determined and used for atmospheric correction. This procedure is simple, but relies on the accuracy of the atmospheric correction for the VEGETATION image. Since only histograms need to be computed, this procedure will be computationally economic.

The second method, which has potential is to use simplified atmosphere models directly such as the SMAC (Rahman and Dedieu, 1994). Compute code for SMAC can be obtained and modified to various spectral bands of other sensors. Once coded, the method will be applied routinely to correct for atmospheric effects.

A third method involves the use of pseudo invariant objects found within a scene. This technique (Chavez, 1988, Qi et al., 1999) appeared to be attractive because of its use of objects of known reflectance properties. This method first identifies at a minimum two objects that are assumed to be invariant (throughout time). Their reflectance properties are known, or can be measured. The reflectance properties of the objects and their associated raw digital numbers can be plotted and the slope and intercept can thus be obtained, which can be subsequently used to correct for atmospheric effect.

These methods can be tested within the FC-IT

5.3 Bidirectional Normalization.

Because of the large area coverage from coarse resolution sensors such as VEGETATION and MODIS, each pixel in an image will have different geometric properties in relation to the sun and the sensor. Pixels away from the center of the image will have a substantially large viewing angle, resulting in different levels of brightness due to bidirectional effects. Many numerous studies have shown that bidirectional effects can be substantial and the effect on subsequent derived products, such as vegetation indices, can be greater than 20%, larger than atmospheric effects found in most cases. Even satellite imagery, which is acquired with a near-nadir angle, brightness can still vary significantly due to seasonal changes in sun elevation. Therefore, it is critical to correct such brightness difference due to solar zenith angle variations, in addition to correct for effects due to varying view angles.

Many BRDF models have been proposed (Strahler, 1994, Cabot et al., 1994, and Strahler1997) to simulate the bidirectional reflectance distribution functions. Most of them were developed for specific vegetation canopy types. Sensitivity analysis suggests that simple empirical models perform as well as many of the sophisticated models. In order to use these models to correct remotely sensed imagery acquired at varying viewing angles, simple models such as those proposed by Roujean et al. (1992), and the Walthall (1985), could be used to normalize the effect due to difference in sun elevation and the sensor's viewing angles. For all images acquired at different dates or different time, which results differences in solar zenith angles, will be normalized to a standard solar zenith angle.

5.4 Cloud Screening.

Persistent cloud appearance in some regions often masks remotely sensed imagery. This will be important for our daily dataset from optical sensors. The techniques that could be used include maximum compositing (Holben et al., 1986) and those described by others (Goward 1990, Gutman 1991, Cihlar et al., 1994, and Qi and Kerr, 1997). The former technique uses the normalized difference vegetation index (NDVI) as threshold to screen clouds. Pixels having the maximum NDVI values from multitemporal images are selected to form a new composited image.

The techniques by Qi and Kerr (1997) use combination of NDVI, viewing angles, and temperature. These techniques retain all pixels above predefined thresholds. In addition, these techniques also retain as all pixels as long as they passed through the selection process, which retain more value data. In focus areas where in-situ data are available, the latter techniques will be used while for global scales the former (Holben, 1986 and Cihlar et al., 1994) technique will be used to composite all images.

5.5 Mosaicking.

Once images have gone through all processes mentioned above, they could be mosaicked to cover the product areas. Although the previous processing procedures will improve the data quality, it is expected that there still be discontinuities across joining boundaries of two images. If this occurs, it may be necessary to use an overlap area matching method to reduce the discontinuity. The outputs from this procedure would be georeferenced, atmospherically corrected, and mosaicked data of the specified spatial and temporal resolutions specified above.

6.0 FOREST COVER PRODUCTS

6.1 Global Land Cover

The land cover product should be produced every five years, with completion of the product 12-24 months following the end of the baseline period. While global land cover with 250m to 500m resolution will have the highest applications value, in the near term a1000m resolution data set is most practical and feasible. However, it is important to recognize the long-term requirement for higher resolution global land cover products.

The level of thematic detail should be greatest for woody vegetation (i.e., trees, shrubs) and only general land cover types are necessary for the other landscapes. This means that there will be uneven categorical detail, with 40-50 classes representing woody vegetation, and approximately 5-10 additional categories representing all other cover types. A draft land cover legend is presented for discussion in the Design Strategy document on the GOFC web site.

While several training procedures and classifiers have recently been used to develop global land cover data sets (i.e., Defries, et al., 1995; Loveland, et al., submitted), there is currently no clear evidence to suggest that one approach is superior to another. The selection of a method must therefore be based on applications issues, including degree of required flexibility and tailoring of the GOFC global land cover product, frequency of updates, and implementation considerations. This should be a major activity of the FC- IT.

For this product in the early stages of development, a centralized production model, in which one organization develops the product, has advantages and offers greater chances of global consistency at a lower cost and completed in a shorter period of time. A decentralized approach is more relevant for policy applications and ecosystem assessments in which it is essential that local to regional landscape conditions are most reliably represented. The decentralized production approach is amenable to those regions where a GOFC Regional Network has been established and has capabilities. In addition, specialized regional products could be developed at the coarse resolution with a legend specifically tailored to regional requirements. With a decentralized model or for regionally specific products, it is necessary to standardize inputs, and definitions of results.

Product validation is important, and could be conducted through a global scheme coupled to high resolution acquisition scheme implemented globally, or through regional activities involving the Regional Networks

Data sets targeted for the global land cover products include MODIS, VEGETATION, and similar sensors, which would be acquired through a specific acquisition model to be developed by the FC-IT.

6.2 Global Forest Density and Percent Tree Cover

An integral part of the global land cover product is a forest canopy density product that provides estimates of percent tree canopy for each pixel. The density would be described in terms of percent forest cover within the pixel, varying from 0 in locations with no woody cover to 100 for locations with full canopy cover. The resolution of this product should be the same as that used in the global land cover product. This data set should be produced every five years, but will be needed within 3 months following the end of the baseline period so that it can be used in the global land cover classification process.

The land cover classification will provide information about forest type stratified according to threshold values for canopy closure. Additional information on forest density will allow comparison with other classification systems using alternate definitions and thresholds for canopy cover. A forest density layer will also allow the identification of locations undergoing changes in forest density that would not be detectable if only considering the land cover type. This information is required to monitor changes in canopy density and to assess the condition of forests. From the point of view of the scientific user, this information permits the modeling of carbon and other biospheric properties that would not be possible with the land cover layer alone.

Processing of the forest density layer, though requiring alternate algorithms, would be done in parallel to the generation of the land cover map with a 5 years frequency. Processing for the forest density layer would be done for those pixels classified as woody vegetation in the land cover map.

Several algorithms have been developed and applied to generate forest density maps on regional and global scales. These methods generally fall into three categories:

- Endmember linear unmixing. In this approach the proportion of vegetation types are deconvolved based on the assumption that the spectral signature is a linear combination of reflectances from the components within the pixel. Implementation of this method requires knowledge of reflectances of "pure pixels" from spectral libraries, field measurements, or high resolution data. This approach has been applied at regional and global scales (i.e., Adams et al., 1995; Bierwirth, 1990; DeFries et al., submitted; Pech et al., 1986; Quarmby et al., 1992; Settle and Drake, 1993). Recently methods have been applied to incorporate nonlinear mixtures (Foody et al., 1997) and multiple endmembers (Roberts et al., in press).

- Spectral regressions. This approach is based on empirical relationships derived from coregistration between fine resolution (e.g., Landsat TM) and coarse resolution (e.g. AVHRR) data. The empirical relationships are then extrapolated over larger regions to estimate percent forest density (DeFries et al., 1997; Iverson et al., 1989; Iverson et al., 1994; Zhu and Evans, 1992; Zhu and Evans, 1994).

- Calibration of areal estimates from spatial aggregation of classifications derived from coarse resolution data. These methods can be used to derive areal estimates of forest cover based on classification of coarse resolution data. The method adjusts the areal estimates taking into account the spatial arrangement of land covers at fine resolution (Mayaux and Lambin, 1995; Moody, 1998).

These methods have all been successfully applied. A comparison of these methods for selected area needs to be carried out by the FC-IT to determine which is the most feasible in an operational context.

The forest density product should be produced in parallel to the land cover map product. Coregistration with the fine resolution product will be needed to assure consistency in results. The post-launch MODIS product generating continuous fields of vegetation characteristics provides an additional link that might useful in the implementation of GOFC.

The forest density product requires validation to provide information on the reliability of the continuum of density values. The validation of the density product may be done using methods similar to those used for the biophysical products. The forest density validation could use high resolution data and ground studies to assure accuracy. This should be carried out for a small number of selected locations.

6.3 Global Forest Cover Change Identification

Although precise estimates of changes in forest cover and density sufficient for such analyses as deforestation assessment and fragmentation analysis needs to be developed using a suite of fine resolution methods and data, a global product would provide a high level identification of areas of significant changes. A global forest cover change product would identify on an annual basis locations where changes in forest condition are occurring. This product would be linked with the fine resolution product so that more in- depth analysis at higher resolution could be carried out for these locations. The forest cover change product would serve as a flag for detecting change in forest cover.

A separate forest cover change product is needed, as opposed to comparison of classification products, because: 1) change detection methods that do not rely on successive comparison of land cover classifications are known to be more accurate; and2) changes in forest cover need to be detected on a more frequent basis than the five years recommended for the global land cover classification product.

The forest cover change product to be generated at a spatial resolution of 250m, the resolution necessary to detect clearings and modifications of forests by human activities (Townshend and Justice, 1988). The product would be produced annually and would be compared to a baseline extent of forest cover as well as to the previous 5 years. The FC-IT would define a standardized method for deriving this product, including source data and methodology, to be established by a coordinating group and that the product be generated on a continental or regional basis by various organizations.

Many methods have been used for change detection based on satellite data. Analysis of radiometric differences between dates generally provides more accurate results than analysis of difference between classification results because the latter compounds inaccuracies in the classification products. Radiometric analysis includes band differencing, band ratioing, transformed band differencing, principal component analysis, and multispectral or multitemporal change vector analysis (Singh (1989) provides a review of these methods). A key requirement for a methodology to be operational in GOFC is that the process be automated as much as possible with realistic computing resources.

In the initial phases of GOFC, we recommend that the change detection product focus on changes in forest extent. In the future, this would be expanded to cover other types of land cover conversion such as agricultural expansion.

The forest cover change product would be strongly linked to the fine resolution products. Identification of areas undergoing change would be flagged for more in-depth analysis with finer resolution data. It will also require linkages with the land cover map and fire scar product to assure consistency. The MODIS 250m and 1km land cover change products might serve as a useful linkage for GOFC.

A strong verification process will need to be an integral component of the method. This will involve high resolution data and a sampling strategy on the ground.

6.4 Regional Land Cover

Regional datasets from coarse resolution data similar to that used for the global datasets can be produced. It is also possible, and desirable at the regional scale to produce land cover maps from fine resolution datasets. In future years, a global land cover dataset can be envisioned from fine resolution datasets but in the initial years of the FC-IT effort, these will be used for regional products.

The first regional high resolution product is a Forest Cover Characterization product, produced on a wall-to-wall basis at 30 meters every five years. This product will support the requirements for forest composition and inventory with detailed classification forests based on methods, which define classes based on functional characteristics.

The products from high resolution observations take advantage of recent advances in developing functional classification of forest cover which are demonstrating the potential for classifications schemes with detailed classes. The Forest Cover Product classification scheme will be compatible with the coarse resolution classification scheme. This should permit a close linkage for calibration and validation, as well as inter-product and inter- scale compatibility. Detailed land cover products for national use can also be developed. These may have specific classifications relevant to national needs, but when ever feasible versions of the product, which can provide regional harmonized products would be desirable.

The classification scheme for this product can be elaborated further to follow the convention described in the table below in which forest types are classified based on functional and structural conventions. This proposed product is deemed both feasible and compatible with the coarse resolution team’s recommendations.

Table 1. Specification for the Regional Forest Cover Product

Leaf Type	Needle, broad, mixed
Leaf Longevity	Evergreen, deciduous, mixed

Canopy Cover %	>60, 40-60, 25-40, 10-25
Canopy Height	Trees >2m, Tall shrubs 1-2m, low shrubs <1m
Other Classes of Cover	Snow/ice, water, grassland, barren, built-up, agriculture, wetlands (orchards, plantations are optional)

This classification makes framework for a fractional forest cover product for detection of subtle changes within forests.

6.7 Regional Fractional Forest Cover and Change

Forest cover changes may be subtle, particularly those changes associated with degradation and selective logging. At the regional scale using high resolution datasets, it is possible and desirable to produce fractional forest cover datasets for assessing these kinds of changes. Degradation and impoverishment of forests by deforestation, selective logging and other factors can be indicated in biophysical properties such as leaf area index, total above ground biomass, and ability to absorb photosynthetically active radiation. These properties are also important characteristics of forest for carbon sequestration and are critically needed for modeling energy and carbon fluxes.

Forest density can be viewed as having two components: a horizontal or spatial component, and a vertical component through the canopy. We could focus our effort on two data products to specify forest density using methods of direct parameterization: (1) a new algorithm which computes fractional forest cover, and provides continuous fields rather than the heretofore traditional classes of forest extent or forest type and (2) Leaf Area Index, which will provide a vertical component of forest density. Taken together these provide a 3-dimensional characterization of the forest. Leaf Area Index would be a collaborative effort of Implementation Team on Forest Biopshyical properties.

We can use fractional cover (*fc*) as an indicator of fine scale forest density and its change. By definition, *fc* is the fraction of area occupied by trees per unit area. For mature forest, *fc* would be 100% while for clear-cut forest *fc* would be 0%. Unlike traditional classification techniques, which classify a pixel either as forest or non-forest, *fc* is a continuous variable that characterize “how much” is forest or trees. Therefore, *fc* can be applied to an entire area to quantify how much of that area is occupied by forest, or applied to a single pixel to indicate the percent area being occupied by trees. This indicator specifies “how much” an area is occupied with trees/forest, but does not indicate “where” they are. Nevertheless, *fc* is a general indicator of forest density of lateral tree distribution. It complements the leaf area index, which is a more vertical distribution of leaves or branches. In addition to being an indicator of forest density, *fc* can also be used in many cases as a forest health indicator such as forest fragmentation and as a measure of forest disturbance.

The fractional cover of forest or trees can be estimated from remotely sensed imagery using an number of techniques, including those derived from linear mixture models (LMM). One potential model assumes that a pixel is a result of contribution two components: forest and soil/liter substrate. The fractional cover of the forest is *fc* and therefore the substrate is 1 – *fc*. The resulting signal, S, as observed by a remote sensor can be expressed as $S = fc \, x \, Sv + (1 - fc) \, x \, Ss$, where *Sv* is the signal contribution from the forest vegetation component and Ss from the substrate. When applied in the reflectance domain (Maas, 1998), equation (1) was used to successfully estimated cotton percentage cover. When used in vegetation index domain (Zeng et al., 1999, and Qi et al., 1999), fractional green vegetation cover can be mapped at different spatial scales.

6.8 Regional Forest Change

Specific area and spatial changes in forest cover can be defined over very large regions at very fine spatial resolution. This product will be used to provide regular maps and quantitative estimates of forest loss from deforestation. This product will be a forest-non forest extent map reproduced on a wall-to-wall basis every five years. Image change detection will then be used between dates to define the specific transitions and changes: forest to non forest, and non forest to forest. In addition, forest change will be measured on an annual basis using stratified sampling between the semi-decadal complete inventories.

This product will measure and map the change in forest cover using precise image-to-image change detection methods. Unlike the Forest Cover product, which will be independent classifications at different dates, this analysis will be focused on change detection. To keep the analysis simple and straightforward, the product will describe "that which is forest at t=1 and is no longer forest at t=1." The product will also report areas of non-forest, which returned to forest. This analysis will be conducted using change pairs 5 years apart, providing a change period of 5 years globally. The five-year period will be compatible with the 5 years period of the Forest Cover Product.

To support RAD requirements, and most of the carbon cycle requirements, an annual assessment will be completed using stratified sampling. A forest-no-forest classification is implicit in this change product, but will be compatible with the Forest Cover Product at the five-year milestones, so changes on a semi decadal basis will be resolved into forest types, while the inter-milestone stratified samples will not (but could be inferred).

It must be noted that in order to produce a forward-looking stratified sampling scheme for change detection, an initial "wall-to-wall" assessment would have to be made in the first 2-3 years. This initial change would define the first stratification until another assessment is made after 5 years. Thereafter the change stratification would be derived from the previous 5 years analysis. It is also important to note that the stratification scheme would be developed in coordination with the coarse resolution team, using important indicators of change as strata (e.g. fires).

Table 2. General Description of the Forest Cover Change (FCC) Product

Resolution	50 meters
Frequency of update	5 hears (with initial 3 years update to

	support the sampling product stratification)
Data sources	Mostly Landsat, with gap-filling by Spot and SAR
Mapping Units	Preserve all pixels, no filters
Coverage	Wall-to-wall, in areas of forest identified by coarse resolution
Thematic classes	Forest, Non Forest
Data acquisition strategy	Landsat 7 acquisition every year, 4 times annually, focused on areas of forest cover and rapid changes, using Spot and other optical as gap filling, with SAR for gap filling. Change pairs must be of the same sensor type.
Processing requirements	Registration to earth coordinates to ? 60 m, atmospheric correction required (coordinated with coarse resolution), change detection using image co-registration to ? 15 m precision)

Table 3. General Description of the Sample Forest Cover Change (FCC-s) Product

Resolution	50 meters
Frequency of update	Annually
Data sources	Mostly Landsat, with gap-filling by Spot and SAR
Mapping units	Preserve all pixels, no filters
Coverage	Based on stratification sampling scheme
Thematic classes	Forest, Non Forest
Data acquisition strategy	Landsat 7 acquisitions every year, 4 times annually, focused on areas with most of the area changes, using Spot and other optical as gap filling, with SAR for gap filling. Change pairs must be of the same sensor type

Processing requirements	Registration to earth coordinates to ? 60 m, atmospheric correction required (coordinated with coarse resolution), change detection using image co-registration to ? 15 m precision.

6.9 Regional Forest Fragmentation

The high resolution analysis at the regional or national scale can provide datasets which can then be characterized using fragmentation statistics. A special product that would provide patch and edge characteristics would be developed.

7.0 PRODUCT VALIDATION, EVALUATION, AND OUTREACH THROUGH REGIONAL NETWORKS

We need to develop and refine our products through collaboration with existing and future GOFC Regional Networks. There are three levels of effort needed, as described below.

7.1 Product Definition and Algorithm Development.

Working closely between the FC-IT and the GOFC Regional Networks, the algorithms can be developed for a range of forest conditions and environments. Working from the start with the Regional Networks is deemed crucial in order that the products not be created in a "black-box," with only theoretical expertise and input. Detailed knowledge of land cover in the focus countries, possessed by the invited individuals, will prove invaluable to the early remote sensing activities.

7.2 Calibration and Validation at Field Sites.

It is important that the remote sensing products must be technically sound, and usable in practical terms. This will involve calibration, validation, and evaluation activities involving our Regional Network collaborators at specific sites. Once we have calibrated the product, it must be validated. For instance, fractional cover measures derived from satellite ought to agree closely with observed cover on the ground. Validation will follow a specific procedure in collaboration with the regional scientists and users. Acquisition of special image data, such as commercial IKONOS data, may be necessary.

7.3 Product Evaluation.

Equally important as validation, the form in which the products are presented for forestry monitoring purposes must be considered and evaluated. In some respects, evaluation will be an ongoing process given the project design, which includes the involvement of network scientists, forest management professionals, and other users from the very beginning. Thus, depending on the application or institutional capability of the administrative unit charged with forestry management and monitoring, the products could be presented in digital or map form, for jurisdictional units of various sizes, and as yearly information or averages over some time period. Our regional collaborators will be able to evaluate the presentation forms of the products, and judge those most suitable for their uses.

7.4 Operational Outreach.

Operational outreach comprises the technology transfer component of the project. Here, it will be necessary to stage workshops for potential users from individual countries as well as the international community. Another approach is to involve user agencies in regular assessment workshops or conferences

APPENDIX 2.

APN FUNDED GOFC PROJECT FOR SE ASIA

1.0 TITLE: SPATIAL DATA AND INFORMATION FOR LAND USE AND FOREST ASSESSMENT AND MANAGEMENT

PROJECT REFERENCE: 2001-09

1.1 Detailed Proposal

This proposal will support the development and distribution of new data and data products for land use and forest monitoring and management. The aims of the project are to support the Asia regional Global Observations of Forest Cover (GOFC) program, and to develop research and training leading to an operational approach that can support three communities:

a) Global change research focused on the role of land use and forest change in the global carbon cycle,

b) National forest management agencies which are faced with real-world problems of forest management in the face of global change, and

c) International policy in particular the IPCC, with a special emphasis on the conclusions of the IPCC Special Report on Land Use, Land Use Change and Forestry, to which PI Skole was a Lead Author.

The project has three proposed Activities each producing a set of products designed to satisfy a group of users:

1.1.1 Activity 1: Implementation of the Tropical Rain Forest Information Center to support GOFC data requirements and users in the region.

We will utilize the basic infrastructure of MSU's Tropical RainForest Information Center (TRFIC) as a means for data processing, product generation, and user support. The TRFIC will be extended to the region by establishing two new nodes: one at UKM in Malaysia, an done at BIOTROP, Bogor, Indonesia. The TRFIC is a NASA supported Earth Science Information Partnership (ESIP) which is currently serving the global change research community and others with historical Landsat data, Landsat 7 data, SAR data and some derived products for the humid tropics (see http://www.bsrsi.msu.edu/trfic). Data and products can now be ordered using a web-based interface and the TRFIC Core System (TCS), an automated information system for processing user requests. This proposal will build on this existing work as an essential element of the project, but *we seek funds only to install the regional nodes*.

1.1.2 Activity 2: Development of New Datasets and Data Products.

This activity will have two components: (1) First we focus on enhancing the existing data products from TRFIC by adding atmospherically corrected and geocoded Landsat MSS, TM, and ETM+ data. This will be especially important in certain Asian regions without good GCPs. (2) Second, we will develop new derived data products including 30 m and 1 km resolution Fractional Forest Cover derived from ETM+, Spot VEGETATION, and MODIS. We adhere to the design specifications for products proposed in Ahern et al 1999, *A Strategy for Global Observation of Forest Cover*, but with modifications from the regional teams reports following the Bogor, Indonesia Workshop which occurred January 2000.

1.1.3 Activity 3: Product Validation, Evaluation, and Outreach.

The project will work closely with collaborators in Asia to develop end-to-end tests where *in-situ* data such as stand inventories are integrated with remote sensing data. We have collaborated for a long time with an existing network of regional scientists funded under the NASA LCLUC Program, APN, and START, and have well-established field sites throughout the region. The current collaborative work with these colleagues focuses on basic research understanding land cover change and carbon cycle questions: this proposal is to expand this work to include the needs of forest resource management in an operational sense and so we will focus our efforts working with foresters in the region. These efforts will provide for data calibration and validation, and will also provide a test-bed for evaluation of the efficacy of the remote sensing merged with in-situ data for operational forest management needs.

1.2 APN Funded Portion

APN funding would support the following:

- One workshop in the region focusing on techniques for fractional cover analysis using SPOT VGT and Landsat ETM+ data with emphasis on inputs to global climate change models (2 members from each of the 7 SE Asia countries and from the USA and 1 from Japan)

- Three calibration/validation field studies in the region: Cambodia/Vietnam, Laos/Thailand and Indonesia (One member from USA and one member from each of the countries where work will take place)

- Two technical visits: one to Malaysia and one to Indonesia to establish TRFIC data nodes.

- Support for the technical development of the products at Michigan State University. These funds will go to support PEPSEA candidates from the region (see Capacity Building below)

1.3 Relationship to Priority Topics in the APN Research Framework

The proposed work in this project as well as the related previous and on-going work of the science network highlighted in this proposal has emphasized the application of empirical land use and land cover data derived from direct observations using remotely sensed imagery to help answer local, national and regional scientific questions of the human dimensions to LUCC, the bio-physical, socio-cultural and economic consequences of LUCC and as inputs to modeling global climate change. The products and training identified in this proposal further these science goals in general and specifically link to the APN priority topic of "Climate Change and Variability"

2.0 REGIONAL COLLABORATION AND COORDINATION

Much of the preparatory work has been done under prior collaborative LUCC projects with the SE Asian Team of LUCC scientists. In fact several meetings have been held in the region to establish a research network that could support GOFC.

The latest workshop was held in Bogor, Indonesia January 2000. The report of this workshop can be found http://www.fao.org/gtos/gofc-gold/docs/sea_gofc.pdf.

The project will coordinate with the APN and IGBP LUCC research network in the region. The network has already been heavily involved with GOFC. Dr. Iwan Gunawan, a co-investigator is the co-chair with PI-Skole of the Forest Cover International Implementation Team for GOFC (see www.fao.org/gtos/gofc-gold/). Others have been involved from the beginning of the design phase and through the initial implementation. Two important workshops, with joint sponsorship by START, have been important in developing the coordination mechanism necessary for implementation of a regional network. The first was held in Washington DC to develop an overall working strategy for tropical regional networks. The second was a workshop in Bogor, Indonesia, which laid out the plan for regional network operations.

3.0 CAPACITY BUILDING

The use of new techniques and technologies in analyzing RS data for fractional cover will be the focus of the workshop. The use of field calibration instruments will also be discussed and used during the fieldwork tasks. To support training, graduate students from the region will work on advanced degrees in the BSRSI program and Michigan State University under the Personnel Exchange Program for South East Asia (PEPSEA), which has been established within the LUCC team's network to build long-term technical and scientific capacity. These students will work on this project and receive degrees in GIS or Remote Sensing from the Department of Geography at Michigan State University, under the BSRSI and will return to the region following completion of their program.

4.0 LINKS TO POLICY

Primary to the work in this proposal is the application of new products for resource managers. Linkages have been established at national levels between the team scientists and forestry agencies. The goal is to establish an operation forest monitory program for resource managers and policy makers and all levels: local to regional.

Individual team members often operate within these levels providing expertise in watershed maintenance, input to national forest assessments and participate in regional, bi-lateral groups, and the come from diverse working environments: university, research institutes, national agencies and NGOs.

5.0 RELATIONSHIP TO GLOBAL CHANGE RESEARCH PROGRAMME

This project builds upon previous work initiated under START with the IGBP LUCC core project activity in SE Asia., in coordination with IHDP with funding from GEF. It also builds upon the work completed under the NASA LCLUC program. It continues this research focus with additional data sets and new methods to support a new global change research program, the Global Observation of Forest Cover (GOFC). Please see http://www.fao.org/gtos/gofc-gold/ for more information on GOFC.

This proposal seeks to support the GOFC project in Asia by providing new data and data products for the region's forests and other important land covers (e.g. rice and urban areas). Part of the project will be further development of the emerging LUCC research network to include forestry-related agencies and institutions. As such we also propose a series of demonstration projects to 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.

A community consensus design for the GOFC project has been developed through a series of international workshops and is described in several documents that describe its central themes and proposed products. These may be viewed at http://www.fao.org/gtos/gofc-gold/documents.html. The GOFC project aims to develop and demonstrate operational forest monitoring at regional and global scales by developing prototype projects along three primary Themes: :(1) *Forest Cover Characteristics and Changes* (2) *Forest Fire Monitoring and Mapping* and (3) *Forest Biophysical Processes*. This proposal seeks primarily to support the development of GOFC Theme (1) with lesser support to Theme (3)

Our goal is to enhance existing data from Landsat and Spot VEGETATION, and future data from MODIS, by applying atmospheric correction and geo-registration. In addition, we recognize that tropical forest change mapping presently has been heavily focused on mapping deforestation using methods that provide digital maps of forest and non-forest. Two new developments in global change remote sensing make our proposal possible. The first involves the use of high spatial resolution optical data from Landsat 7. Launched in April of this year, data are now being acquired using the Long Term Acquisition Plan, which will acquire cloud free data at least once per year for the entire tropical belt. The overall objective of the LTAP is to provide a global refresh 4 times each year, capturing data for both inter- and intra-annual measurements on a routine basis.

6.0 RELATED RESEARCH WORK

§ *NASA Landsat Pathfinder*

- *IGBP LUCC – SE Asia: Four Case Studies in Thailand, Malaysia, Philippines and Indonesia*
- *NASA LCLUC – SE Asia: Interannual Dynamic of Forest Cover Characteristics and ModelingHuman Dimensions of Land Use/Land Cover Change*
- *APN 2000-2001 – (PI-Dr. Sharifah Mastura S.A)*
- *GOFC*

APPENDIX 3

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Work Plan and Time Line

	2001						2002					
	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March
UKM Node		----G (Five day visit)										
BIOTROP Node		-----G (Five day visit)										
Product Dev.	--on-going with PEPSEA--------											
Field Wk./Val 1 & User Outreach						------G (Five days each of two countries)						
Field Wk./Val 2 & User Outreach							-------G (Five days each of two countries)					
Field Wk./Val 3 & User Outreach								------G (Five days in final country)				
Workshop/Product Outreach								------G (5 day workshop)				
Report Writing									---------G (Final Docs due 3/15/02)			

Date	Venue	Event	Estimated Number of Participants
29 Nov – 3 Dec. 2001	Lotus Pang Suan Kaew Hotel, Chiang Mai, Thailand	Workshop on end user product outreach	17 SEARIN Personnel (funded) and 15 – 30 Regional “end user” participants (non-funded)

UKM Node and BIORTOP Node

Assistance in the installation of software and hardware, the creation of an RDBMS populated with remote sensing satellite imagery metadata, and the establishment of Internet connectivity between these nodes and the Tropical Rain Forest Information Center to serve data to users supporting a variety of national resource management and scientific activities throughout the region. These nodes will facilitate the ease and access of data for end users, as well as provide archive opportunities for future products being developed through R & D efforts and by natural resource managers themselves.

Product Development

This project will focus on development of a suite of datasets and data products as follows(see Table 1 below):

Level 1 TM and ETM+ data from TRFIC, which are not atmospherically corrected and geo-referenced by system correction only will be made available. In addition, we will acquire SPOT VEGETATION and MODIS images over the tropical forest areas.

Level 2 Enhanced image datasets, which will include fine and coarse resolution image data from TM, ETM+, ALI, MODIS and VEGATATION which have been atmospherically corrected, geo-referenced to earth coordinates (+ 60m), projected,normalized for view / sun angle effect, and mosaicked when multiple scenes needed will also be provided.

Level 3 Derived data products, which will include the results of analyses of image products using new algorithms, which compute fractional forest cover and LAI. These products will be used to improve existing assessments of deforestation, re-growth, logging, and forest cover characteristics.

We believe that some users will primarily need access to the Level 1 and Level 2 datasets, such as the UN FAO Forest Resource Assessment program which routinely acquires the image data and performs its own in-house data analysis. Others, such as the forest inventory community need access to Level 3 derived data such as extant forest density and fractional cover for making forest inventory or deforestation and forest degradation assessments.

Product Level	**Product Description**	**Spatial and temporal coverage**
1a	Raw TM and ETM+ from TRFIC, no atmospheric correction, geo-referenced by system correction only.	Focus area: 30m/1yr Regional: 30m/3yr
1b	Raw VEGETATIPON and MODIS imagery, no atmospheric corrections, geo-referenced by system correction only.	Focus area: 1km/month Regional: 1km/month
2	Geo-referenced and atmospherically corrected, normalized for sun and view angles, 30m and 1km resolution imagery from Landsat, supplemented with EO-1, SPOT, and ASTER imagery. Spatial accuracy ?60m	Focus area: 30m + 1km)/yr Regional: 30m/3yrs & 1km/month
3a	Forest Density (FD): Forest fractional cover computed from geo-referenced ETM+ and MODIS/VEGETATION imagery	Focus areas: 30m/1yr Regional: 30m/3yr & 1km/month
3b	Forest Density (FD): Estimated total green leaf area index and fPAR using MODIS LAI/fPAR algorithm, optimized for tropical forest.	Focus area: 30m/3yr Regional: 30m/3yr & 1km/month

Timeline for Product Development

	2001						2002					
	April	**May**	**June**	**July**	**August**	**Sept.**	**October**	**Nov.**	**Dec.**	**January**	**Feb.**	**March**
Product Dev.	---------------------------------1a Prod. --------1b Prod. --------------------------------2 Prod. ----------------3a Prod. ----------3b Prod. ---											

Level of Product	Est. Completion for Southeast Asia Region
1a	June 30, 2001
1b	August 15, 2001
2	October 15, 2001
3a	December 15, 2001
3b	February 1, 2002

Field Work Activities and User Outreach

These activities will take place in the following countries: Thailand, Laos, Cambodia, Vietnam and Indonesia. Activities will center on gathering feedback from end users (Forestry agencies, Natural Resource Management Agencies, planners, etc.) regarding new products, access to data, data formats, and data delivery mechanism. End user requirements will direct any specific "course corrections" necessary in the product development and data distribution scenarios. Field site visits with end users will help to validate product accuracy. These activities will occur in three field visits: one in Thailand and Laos, a second in Vietnam and Cambodia and a third in Indonesia. Work will span five days in each of the five countries. End user information collected in this activity will flow back in the form of document summaries distributed to government agencies, NGOs etc., and through the development of a web site. This will help facilitate on-going user feedback and continued discussion directed at user requirements to help focus the product development strategy.

Final Workshop

A final workshop will be held in the region late November or early December 2001 focused on product outreach and continued end user product support. This workshop will serve as a capstone to the previous eight months work in which collaborating agencies will have an opportunity to share developed products (data on CDROM, photo products, posters, policy briefs, documents, etc.) and develop future plans to support other agencies with this data and information at local to regional levels.