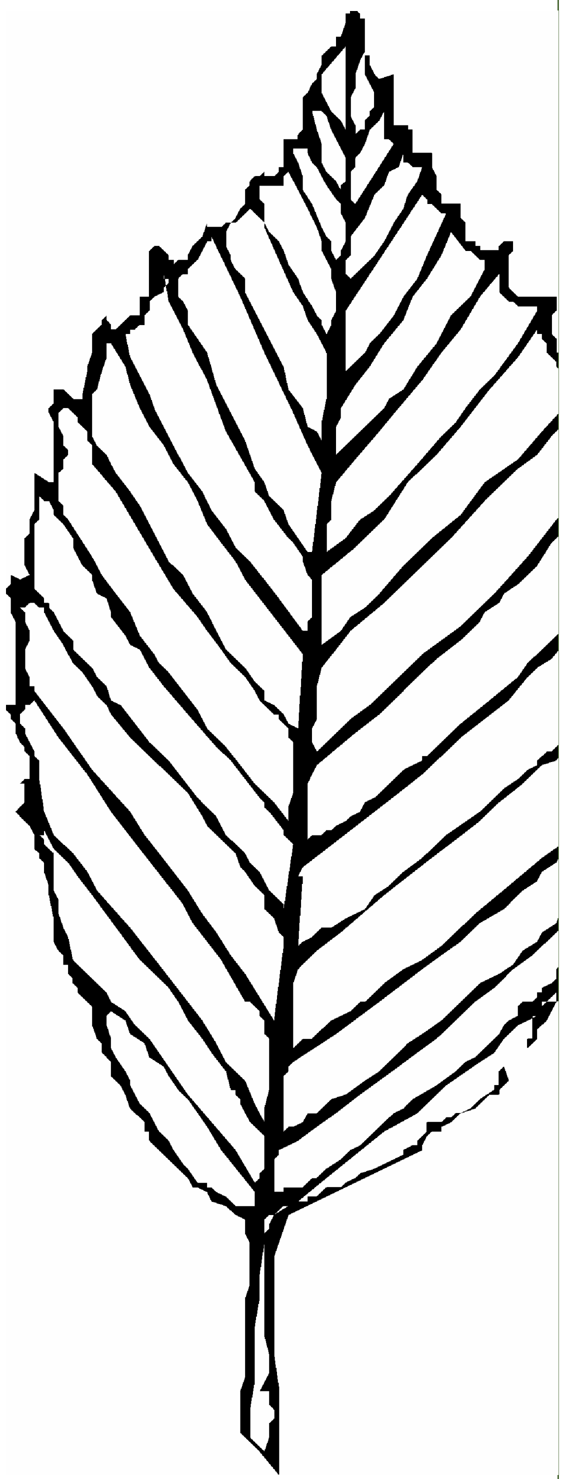
Integrated Global Observations of the Land (IGOL) – an IGOS-P Theme

Special meeting on observational priorities for conservation and biodiversity

3-4 November 2005



Hosted by the H. John Heinz III Center for Science, Economics, and the Environment Washington DC

Meeting co-Chairs: Anthony C. Janetos, The Heinz Center
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Introduction and background

The IGOS Partnership (IGOS-P) was established in June 1998 by a formal exchange of letters among the 13 founding Partners for the definition, development and implementation of the Integrated Global Observing Strategy. The principal objectives of the Integrated Global Observing Strategy are to address how well user requirements are being met by the existing mix of observations, including those of the global observing systems, and how they could be met in the future through better integration and optimization of remote sensing (especially space-based) and *in situ* systems.

The Integrated Global Observing Strategy serves as guidance to those responsible for defining and implementing individual observing systems. Implementation of the Strategy, i.e. the establishment and maintenance of the components of an integrated global observing system, lies with those governments and organizations that have made relevant commitments, for example, within the governing councils of the observing systems' sponsors.

For background, readers are encouraged to consult the IGOS Partners web page (http://ioc.unesco.org/igospartners/over.htm) with its description of the land theme (http://ioc.unesco.org/igospartners/LAND.htm) and the scope of IGOL in the original document approved by the IGOS Partnership in Rome 2004 (http://ioc.unesco.org/igospartners/docs/theme_reports/igolversion2.doc).

The meeting for Observational Priorities for Conservation and Biodiversity was convened at the H. John Heinz III Center for Science, Economics, and the Environment on 3-4 November 2005. This report documents the main conclusions reached by the participants (Appendix 1).

Current international context

The Integrated Global Observing Strategy Partnership (IGOS-P) consists of most of the major intergovernmental organisations involved in global governance (eg FAO, UNESCO, UNEP), international research coordination (ICSU, IGBP, IHDP, WCRP, Diversitas), global observations (WMO, GTOS, GOOS, GCOS) and space agencies (CEOS and its member agencies). Its purpose is to coordinate activities in earth observation, on a voluntary basis.

IGOS-P is organised into several themes, each of which develops an approximately 10-year strategy, which is published as a theme report. Examples are the Oceans Theme and Disasters Theme. The Land Theme is in preparation, and this report (Biodiversity and Conservation) is a contribution to it.

Parallel to the IGOS-P programme, which largely deals with technical coordination, is the Global Earth Observation System of Systems (GEOSS). This is a new intergovernmental group which offers the opportunity for political support and coordination of Earth Observations. The GEOSS

10-year implementation plan (Reference) is currently being fleshed out in technical detail, and will rely heavily on the work done under the auspices of IGOS-P. The GEOSS programme is highly user-oriented, and is focussed on nine Societal Benefit Areas (SBA's). Several SBA's have direct or indirect implications for the IGOL Biodiversity and Conservation working group, and vice versa. Biodiversity is a GEOSS SBA in its own right, as is Ecosystem Management. SBA's on Climate, Agriculture (which includes desertification), Disaster and Natural Hazards (eg fires and storms), Water, and Energy (which includes energy infrastructure) are all relevant. The mapping of the recommendations of this report to GEOSS activities is shown in table X. The Biodiversity Working Group report will be communicated directly to the appropriate GEOSS task leaders, as well as feeding into the IGOL theme report, which will be accepted by the IGOS-Partners, and communicated by them to the GEOSS plenary.

Drivers for improved observations of biodiversity and conservation

The erosion of the Earth's biological diversity has exceeded rates documented in the recent geological past (Millennium Assessment 2006), for those taxa that are well-understood. There is every reason to believe that for all practical purposes, i.e. within the time spans that can be affected by human decision-making, these losses are irreversible. But it is not only the loss of biological riches that is an issue. As the Millennium Assessment points out, biological diversity is the foundation of a whole range of ecosystem services that directly or indirectly benefit human well-being. Those services range from provisioning (e.g. food and fiber), most of which are traded in markets, to regulating (e.g. regulating air and water quality), to supporting (e.g. maintenance of soil fertility), to cultural and aesthetic (e.g. recreation and spiritual needs) some of which are priced and traded, and some of which are not.

It is thus important for both immediately practical reasons as well as for broader cultural and aesthetic reasons to understand the observational needs with respect to the drivers of biodiversity loss, conservation action, and the direct consequences of those changes. One conclusion of the Millennium Assessment, for example, was that much of the difficulty in understanding trends and conditions of ecosystems and the services they provide is that there are significant gaps in the observational record.

The special IGOL workshop sought to address many of these concerns by identifying particular enhancements and requirements to the observational programs of agencies around the world. The workshop focused primarily on space-based observations and how they might be used, but considered other requirements as well. Participants also described recommendations for modeling, capacity-building, and in situ/validation programs.

The recommendations summarized below reflect two days of discussion among the workshop participants. They include recommendations for direct observations, for derived products, for modeling, for capacity building, and for data and information systems.

It is also very important to recognize that there is an assumption built into this analysis, which is that there will continue to be a long-term, global set of observations of land-cover imagery that is "Landsat-class", i.e. that is around 30m spatial resolution, with approximately seasonal temporal resolution, and whose spectral characteristics are comparable (but not necessarily identical) with the existing 30 year record of existing measurements.

Recommendations

Within each category below, the recommendations are ranked in priority order, first in the list being the highest priority. The ranking was done through the discussion process at the workshop, involving all the participants. There is no implied ranking among the different categories, however. The assumption that there would be continuity of a global, "Landsat-class" series of measurements was felt by all participants to be of the highest overall prioritiy.

Enhancements to Direct Observations

- 30m global topography. These observations will play a critically important role in both correction of imagery data, but also in habitat delineation, and as input data for a wide variety of models.

- *Very High Resolution Cloud Free Imagery at low cost for rapid response in key areas.* One of the challenges for the conservation community is that in many key regions of the Earth, there is extremely rapid land-cover and land-use change whose consequences for biodiversity is possibly quite large. Existing optical imaging systems suffer from the obvious constraint of not being able to sample through clouds. Radar or pointable optical instruments might be able to circumvent this constraint so that the conservation community could track such activities as illegal logging, road-building in sensitive areas, and so forth, and formulate an appropriate response.

- *Vegetation Lidar type data for structural information.* As important as knowing land-cover is, it is not the only type of information useful for understanding the status or changes in biological diversity. The overall structural diversity of the landscape's dominant vegetation is also extremely important for determining the diversity of animals and plants that depend on it for habitat. Direct measures or proxies for structural diversity would be extraordinarily difficult to derive from most imagery; however, it is well-known that lidars have the potential to make direct measures of structural diversity through the derivation of canopy profiles from their returns.

Enhancements to derived products

- *Long-term record of Land-Cover Change and Fragmentation at 30m resolution.* The critical feature of this product is the use of Landsat-class imagery, and maintaining the continuity of this data stream in an operational mode. The community strongly endorses annual time-steps at a minimum, while recognizing the desirability of seasonally-resolved data. There is particular urgency for ensuring that the first decade of the 2000's is captured because of the problems with Landsat 7, combined with the continuing operation of Landsat 5. There are several possible solutions which the space agencies are currently exploring, including implementing Landsat 5 receiving stations in key areas so that a continuous record in tropical environments can be continued. An important step in this product would be the generation of such a product for the decades of the mid-1970's through ca. 2000, for which global Landsat datasets exist, but for which the product has not yet been realized. A key attribute, or derived characteristic of such a land-cover product would be the derivation of disturbance patterns and frequencies.

- A long-term record of critical land-use characteristics, at a spatial scale that is commensurate with the land-cover change product, but that includes additional information on the human use of land resources. A long-term record of land-cover change be a key component of a land-use data product, and would include the information necessary to derive road and transportation networks, amount and changes in impervious area, and infrastructure changes (e.g. built area, dams, pipelines, etc.). A key attribute of a land-use product would be the inclusion of information on cropping systems that was sufficient to identify crop type, and of sufficient spatial resolution to identify small land-holders (ca. 0.5 ha). In addition, one would want to have associated information on ownership at a categorical level (e.g. private ownership vs. public ownership), on concession status for forests and other natural resources, and for protected areas, a particular emphasis on their status, extent, efficacy of management. The repeatability of the land-use product would need to approximate an annual time-step, but might be slightly coarser.

- Seasonal monitoring of freshwater distribution and flow perhaps sufficient to detect irrigation scheme. There was a strong consensus among the workshop participants that the issues of water supply and flow were important for understanding changes in the status of freshwater diversity, and in the problem of diverting water for consumptive uses in industry, agriculture, and in urban areas. This derived product would require other information to be viable, however, such as a very high resolution DEM for important regions or globally.

- *Adopt consensus ecosystem classification hierarchy and map product.* It is impossible to satisfy needs (such as those from the CBD and many other users) for observing and documenting status and changes in key ecosystems without an *a priori* agreement of how particular ecosystems are defined. Ecological classifications are inherently hierarchical, just as land cover classifications are, and the approaches need to be clearly related to other widely-used land cover classifications (such as Land Cover Classification System developed by FAO). The ecosystem classification approach also needs to be compatible across the land-freshwater-coast-marine continuum, which takes it beyond most existing land cover and land use products, and requires a significant new effort. The theoretical and practical basis for implementing a consistent classification of ecological systems (and the associated mapped products) is now available. The need from users, such as for multiple resource management, conservation, and ecosystem health monitoring applications, is great. Numerous ecoregional level approaches are emerging (e.g. WWF Ecoregions, Large Marine Ecosystems) that provide a coarse higher level description of the landscape. Finer level ecological system classifications are now being created and mapped (e.g., NatureServe Ecological System classification for the Western Hemisphere, TNC/NatureServe Ecological System map for Latin America) to support functional assessments and planning within a region. What is needed is a global agreement on what systems to use, how to map them, how to add detail to them, and to eventually extend them to all ecosystems (including human dominated systems).

- *Improved global soils information.* Soils, like land-cover, occupy a central role in the derivation of a wide range of important land-related products: hydrology, agricultural suitability, land-atmosphere exchanges and the global carbon and nitrogen cycles. Effectively, the world is still depending on a very inadequate global soils map completed in the 1960s for these inputs. A much improved methodology has been developed (SOTER) but incompletely published. The minimum key needs are for moderate resolution (~1 km) probability based surfaces abs soil hydrological properties (field capacity, wilting point and depth per horizon) and biogeochemical properties (clay and silt content and organic carbon content by depth).

- *Landscape condition and degradation product.* One of the main challenges in understanding landscape condition and degradation as both a driver of changes in biodiversity, or as a consequence of other drivers of biodiversity loss, such as overgrazing or rise in the use of fire as a management tool, is that there is no generally agreed-on way to identify and map areas where significant degradation has taken place. This is both a research and an observational need, as the Millennium Assessment has pointed out. A derived product of this sort needs to be defined to be specific with respect to ecosystem, and it should have at least annual temporal resolution, and spatial resolution sufficient at least to match a consensus classification scheme. Particularly in drylands, it is critical to be able to detect significant trends in the underlying capacity of the land to supply ecosystem services and to support biodiversity. This is best indexed by the net primary productivity and by the efficiency by which the land cover converts resources (particularly rainfall) into plant production. NPP itself is ?currently too challenging to measure in situ or remotely, and proxies such as NDVI are probably a little too simplistic. The seasonal time course of FAPAR is a reachable compromise. The efficiency index in the form of ΣFAPAR/Σgrowth_driver. Rainfall is a simple proxy for growth driver, but is probably oo simple to be globally robust. Measured duration of soil moisture would be better, but is still a technical challenge. The compromise is modelled soil moisture duration, based on climatological input data. An emerging key indicator which can be derived from the above by integrating them with socio-econimic data on harvest and livestock is the Human Appropriation of Net Primary Productivity (HANPP). It is appplicable for drylands as well as wetter areas.Of particular importance to immediate biodiversity concerns would be a continuous, global, long-term data set of forest degradation derived from moderate resolution imaging spectroradiometers. Landscape condition parameters would include such system- and process-level components as NPP and biogeochemical cycling, but would also include measurements of habitat type and continuity.

- *Roads,Transportation, and Infrastructure Networks*. A critical derived product of immediate use for understanding potential threats to biodiversity would be a much-improved data base of roads and infrastructure networks, including pipelines, rail-lines, and dams. This data set could be derived from a combination of remotely sensed and *in situ* data.

- *Distribution of species abundances and changes, including changes in particular indicator species (e.g. important resources or invasive species).* One of the main challenges in biodiversity research is to be able to characterize the potential response of individual species to various stresses. Such a data set, which might have remotely sensed components, but which would also necessarily involve substantial *in situ* sampling, would enable time series analysis for response functions.

- *Monitoring of trade in endangered species, bushmeat, etc. through market statistics.* A particular driver of concern such as tracking bushmeat trade can only realistically be done through the participation of the human dimensions community. This type of derived product would be of great interest to those groups who are trying to reduce the pressure of overexploitation of wild populations, particularly in tropical regions.

Models and Model Development

- Improved species distribution modeling. The family of models that are used to predict species distributions on existing landscapes need to have better guidelines for their use by the scientific community and conservation organizations. The models need to better incorporate spatial (e.g. remote sensing) data; including coupling biodiversity/spatial distribution information with geophysical modeling, so that projections can be done with more validity.

- *Model validation for existing products of relevance to biodiversity issues.* A major challenge for model development and use is having independent validation data. The development of a validation data set would include organizing observational data from in situ research sites, as well as validating derived products from remotely sensed data with ground-truthed information.

- *Understanding of provision of goods and services from biodiversity.* While it is true that biodiversity is the foundation of many of the goods and services that human societies derive from ecosystems, the quantitative relationship between particular services and diversity is not well understood in many cases. There is therefore a critical research need to increase our understanding. The workshop did not derive a particular set of observations to support this need, but recognized that this task would have to be done.

- *Urban and rural growth models/data.* The growth of urban areas, and the establishment of settlements in previously rural areas are two of the most profound demographic trends we expect to see in the early decades of this century. Constructing data sets and ultimately models that can represent these changes are going to be very high priority activities for the human dimensions community and the biodiversity research community, as they consider how the drivers of biodiversity losses are likely to change.

- *Scaling GCM's output to be ecologically relevant.* A challenge for the climate modeling community is constructing the output from their models to be ecologically and biologically relevant for projecting biological changes. There are some good examples of this in the literature, and each of them creates new observational requirements, for example the need to have output and therefore observational inputs that roughly correspond spatially with the landscape condition and land-cover fragmentation data sets outlined above.

Enhancements to capacity building

- *Building capacity for imagery processing and interpretation.* An important limitation to the use of observational data, especially the remotely sensed observations, is the institutional and human capacity for image processing and interpretation. The workshop concluded that for the successful use of many of the observational products that we discussed, that this capacity would have to be enhanced, especially in developing countries. There are many successful examples of this having been done, especially among partners of international non-governmental organizations, such as CI, WRI, and WCS. But ensuring that there is continuing support for such activities is a limiting constraint.

- *Peer-to-peer education efforts and outreach about existing (and planned) observation capacity*. The workshop concluded that a second constraint on capacity building is simply the knowledge base about what the observational agencies are in fact planning to do in their programs. This can be relatively easily solved through peer-to-peer education and outreach efforts.

- *Provisions of treaties and other international agreements.* The formal frameworks for many issues relevant to biodiversity and conservation are contained in multilateral treaties and other environmental agreements. Not all of these are explicitly about biodiversity; e.g. the Climate Convention requires countries to report on various types of land-use activities as they relate to greenhouse gas emissions, but much of the same information would be relevant to biodiversity and conservation. A clear need for many countries is to enhance their institutional capacity to make the measurements that the variety of treaty obligations requires them to do, and make that information widely available.

Data and information systems and data policy

Current deficiencies in data and information systems for conservation and biodiversity, center on a number of key issues. This first issue is articulating the manner in which open-source or alternative solutions to access should be defined. The principles of the Conservation Commons represent one such evolving framework. Secondly, it is essential to buy into and improve geospatial accuracy, primarily in non-remote sensing data sources, e.g. taxonomic data bases. Currently there a number of efforts underway to accomplish this goal but they need to be supported in a much more substantive fashion. Third, in the development of information products, the “definitional issue” needs to be addressed, e.g. what qualifies as forest cover and what are the reporting and validation standards. Fourth, although remote sensing data and information sources are beginning to contribute efforts such as Target 2010, this effort needs to be expanded to include a wide variety of stakeholders and indicators. Lastly, it remains essential to infuse the existing environmental science and decision making infrastructures with the long-term capacity to utilize geospatial data.

In terms of data and information policy, the key issue is that policies supporting restricted data access undermine best practice conservation on behalf of all stakeholders, have a negative impact on Party decision making and budgetary processes, decrease the verifiability of conservation findings, and perhaps most significantly, increase the complexity of environmental and biodiversity issues. It should be emphasized that the issue of access is, in part, a geographic one, an example of the North-South, digital divide. The issue of accessibility is not solely on the side of remote sensing, with substantive roadblocks on the side of biodiversity data and information systems. Accessibility does not necessarily need to be carte blanche accessibility with many alternatives in terms of licensing currently in the information community, e.g. the Creative Commons and others.

Accessibility, as the key issue for data and information policy, needs to be addressed across a wide variety of stakeholders. On the Governmental front, the cost-recovery model has historically led to little or no actual cost-recovery and has been a roadblock in accomplishing strategic science and application objectives, as defined by the Space Agencies. In addition to governments, outreach needs to be conducted to a relatively untapped group of data providers: the commercial industry. This, in particular, includes industries with relatively poor historical environmental records but who may have conducted extensive internal environmental assessments and who have a distinct interest in improving their environmental records. Sustained engagement of the commercial satellite industry is also essential as, at least in some countries, they remain the sole source of high resolution satellite data.

For accessibility to be substantively improved, there is the need to integrate not just remote sensing and biodiversity data but also to build capacity within both communities to avail themselves of the others' data and the end integrated products. In the end, the dialogue between the consumer, conservation, community and the provider
Parties needs to be substantially enhanced, with increased buy-in from science, research and applications users. In line with this dialogue, the extant technology infrastructure needs to be responsive to the needs articulated. In conclusion, the need to integrate remote sensing with biodiversity data that is spatial explicit needs to be underscored and, even more-so, it should be emphasized that if the Parties expect their science goals and outcomes to be realized, it will be necessary to articulate a more open data access policy.

Conclusions

The workshop participants reached a great degree of consensus on needs for direct observations and for derived products. These are represented in the recommendations above. In addition, the participants outlined needs for models and model development, enhanced institutional and human capacity for both generating and using data, and reducing data and information management constraints. These are also presented as recommendations along with observational recommendations.

APPENDIX ONE: Workshop Participants

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APPENDIX TWO: Workshop Agenda

Day 1: Thursday 3 November, 9 am start

1. Welcome and introductions (Tony Janetos)
2. Objectives of meeting (Tony Janetos and John Townshend)
3. Agreement on agenda.
4. The Integrated Global Observation Strategy (IGOS) and the Integrated Global Observations of the Land (IGOL) Theme. (John Townshend).
5. Drivers for improved observations. (Tony Janetos)
6. International conventions
7. NGOs
8. Protected Area Management
9. Recent evaluations of observational needs for Biodiversity and Conservation including the IBOY and the Millenium Ecosystem Assessment (Tony Janetos).
10. The Socio-economic dimension (Roberta Balstad)
11. Future remote sensing assets for conservation and biodiversity (Woody Turner).
12. Current efforts at in-situ monitoring to enhance the utility of remotely sensed observations (Doug Muchoney)
13. Recommendations relating to enhanced observations from the first two IGOL meetings (John Townshend).
14. What are the enhancements needed in our observational capabilities beyond those currently reached by the IGOL Theme Team? (Each attendee will be asked in turn to highlight what they regard as the one or two most important deficits in observations or the information products derived from them. There will then be an opportunity for everyone to add additional items.)
15. Summary of 1st Day (Co-chairs)

Day 2: Friday 4 November, 9 am start

1. Review of 1st day and agreement on observational priorities.
2. Identification of responsibilities for improved observational capabilities.
3. Improving information systems for Biodiversity and Conservation.
4. Sharing information: the role of policy.
5. Summary of main conclusions
6. Close of meeting (It is hoped that the meeting will finish at or shortly after lunch. Following the meeting the co-chairs will prepare a report of the meeting: other attendees who wish to participate in this activity are invited to remain).