Part C: An Intensive Biodiversity Baseline Study in Jambi Province,Central Sumatra, Indonesia

Preliminary Report

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SECTION 1: SUMMARY AND OVERVIEW

1.1 Summary:

This section reports the preliminary results of an intensive biodiversity baseline study that was undertaken to establish an improved scientific basis for selecting indicators for biodiversity assessment. The sampling framework centred around a series of 16 (40x5m) plots that were established along a gradient of increasing land-use intensity. While these plots were designed for a vegetation survey, they formed a focal point for co-located surveys of various animal groups and analyses of soil physio-chemical properties and above-ground carbon. A team of 23 national and international specialists in biodiversity assessment undertook the survey in an area of lowland Sumatra that included land-use types ranging from intact rain forest through various logged-over and secondary forests, mixed agroforests and plantations, to degraded grasslands. The survey produced several outcomes that are significant to both science and management. These include the identification of a greatly improved set of plant-based indicators of biodiversity, soil nutrient status and above-ground carbon. The indicators are based on combinations of richness of vascular plant species, Plant Functional Types (PFT) and a ratio of species richness to PFT richness. To these can be added vegetation structure (mean canopy height, basal area in square meters per hectare) that improve the prediction of certain site physical features, and some animal taxa. The combination of plant species, functional types and structure can also be used to generate an overall vegetation index (the “V” index outlined in Part B) that is itself highly correlated with various animal taxa and site physical conditions. A statistical analysis shows that many correlations are non-linear, maximum variance being accounted for by second order polynomial regressions. Exploratory data analysis confirmed that specific combinations of these indicators can be used to identify ‘best bet’ conditions such as jungle rubber, where biodiversity (expressed as richness of taxa and functional types) may in some cases exceed that of pristine forest. The study has established a scientific basis for exploring linkages between plant and animal taxa and functional types, soil nutrition (and thereby potential site productivity) and carbon sequestration. The results provide a ready means of approximating biodiversity patterns across a range of land-use types that typify much of the lowland tropics around the world. This illustrates how plant and animal species richness varies with land use impact. This information provides an improved basis for forecasting the impact on biodiversity of forest conversion to different land uses. The methodology can be readily adapted for use by management where rapid assessment of site conditions is needed, and where site-based information is critical to support adaptive management under changing environmental and socio-economic conditions. The information acquired at this sub-regional scale is generally consistent with that for similar land-use types in other countries. Spatial extrapolation of biodiversity patterns can be readily tested using DOMAIN potential mapping software and the digital environmental data acquired for the Sumatran benchmark site. The survey has generated a series of scientific papers authored by national and international participants. The study also provided invaluable material for case studies that are being included in a multi-media training manual for rapid vegetation assessment as a component of biodiversity.

1.2 Introduction:

This survey was conducted as part of the research program of the ASB consortium. It was designed to address Goal 2 of Phase II of ASB, which is to *"Assess the impact of different land-use practices on biodiversity*". The extreme logistic constraints associated with the ecoregional baseline studies in different countries meant detailed, replicative sampling of ecoregional gradients had to be replaced by an approach that would be logistically acceptable but at the same time could adequately sample key patterns of land use impact. (See survey design below). Because the ASB program is highly multidisciplinary, it was important to co-locate study sites wherever possible. Although sampling strategies differed between disciplines, sites were centred around a common spatially-referenced sampling point (a 40 x 5m vegetation plot). Wide-ranging surveys along several hundred kilometers meant sampling was often superficial, resulting in frequently poor correlates between different data sets. In the absence of an effective calibrational baseline study, it was therefore not possible to establish any useful models of the impact of land use on biodiversity. Another major constraint was the lack of an acceptable operational definition of biodiversity. At the time of this study there was no model or sampling system that was available to help identify useful predictors of change in biodiversity due to land use.

It was clear that in order to develop any useful, testable model of land use impact on biodiversity, the ASB above - and below-ground teams had to start from scratch. Sumatra is known to contain some of the world's highest levels of richness in plant and animal species. Unfortunately, it is suffering major impacts from poorly planned land use arising from land clearing for oil palm and rubber plantations. Because these conflicts typify much of the lowland tropics and because information was already available from earlier CIFOR surveys of representative Land Use Types (LUTs) (A.N. Gillison and N. Liswanti), Sumatra was chosen as the focal area for an intensive biodiversity baseline study. The aim was to first locate a representative gradient mix of LUTs and physical environments and second to sample these according to site physical characteristics, specific vegetation features designed to reflect taxonomic variability as well as adaptive features, and a range of animal taxa (birds, mammals, insects, molluscs). It was assumed the resulting data sets would be adequate for developing testable models of plant and animal response to land-use impact. This procedure would help identify indicators for use in subsequent rapid assessments of impact in similar tropical lowland forested landscapes, thus reducing the need for intensive and costly surveys.

Without some ready means of extrapolating (mapping) findings, results from any survey are of limited use for management. An important focus for this operation was to ensure all data were spatially referenced as accurately as possible. High quality GPS readings (Trimble Scoutmaster using the Acculock system) were obtained mostly with a conservative accuracy of ± 70m. The aim of this approach was to establish adequate spatial data for modeling the potential distribution of plants and animals under different LUTs and physical environments. If shown to be successful, such models would be potentially useful for coupling biophysical interactions with socio-economic models being developed by other ASB groups. It is assumed that by constructing integrated models of biophysical-socio-economic interactions it will become possible to generate options for adaptive management to cope with unexpected variations in climate and market forces triggered, for example, by episodic El Niño and La Niña events.

Multidisciplinary surveys are costly in time, money and coordination. If carefully designed, they can be enormously cost-effective. Forward planning is essential in order to acquire the right mix of international and national specialist for the different plant and animal groups. Planning for the present survey began a year before, and extensive reconnaissance was needed to establish the most suitable location. The assistance of BIOTROP was sought initially, as this Indonesian-based NARS possessed a research station centred in lowland Jambi Province in Central Sumatra with adequate accommodation and electrical power to serve most of the needs of different specialists. Further, CIFOR had established a close working relationship with life-scientists from BIOTROP and ICSEA. For biodiversity surveys, timing is critical as seasonal variations can have a major effect on the nature of the data collected for different plant and animal taxa. Towards the scheduled start of the survey, Jambi was gripped in an El Niño drought that threatened a postponement to the following year. Fortunately a weather change with heavy rain ten days beforehand created near-perfect conditions for a baseline survey. The field operation was conducted between 16/11/97 and 2/12/97. Most taxonomic identifications were completed by mid-1998 via contracts arranged through research institutions in the UK and Australia.

1.3 Budget:

Complete costs are difficult to estimate given that certain salary costs of CIFOR and ICRAF staff and in-kind assistance from partner institutions are not included. The bulk of the in-field survey costs contract fees for specialists and subsequent contracts for taxonomic identification at various research institutes was approximately USD$98,000. Funding was covered in part through ASB (60%) with the remainder from USAID and DANIDA. In retrospect, given the results of the survey, the number and quality of the participants and the high level of infrastructure support, the operation could be regarded as relatively low-cost. A parallel study in more remote and less well supported lowland tropical region such as parts of Kalimantan or West Irian would have been twice as costly.

1.4 Participants:

A detailed list of participants is available in Annex 1, Table 3. A total of 27 scientists and support staff participated in the survey. International specialists were drawn from the British Museum of Natural History, the Institute for Terrestrial Ecology, UK, Oxford University (Depts of Geography and Plant Science), and the University of Malaysia. National scientists from Indonesia were from LIPI (Herbarium Bogoriense, Zoology Museum), SEAMEO BIOTROP, University of Brawijaya and the University of Gadjah Mada. The survey was coordinated by CIFOR (A.N. Gillison) with assistance from Ms N. Liswanti (CIFOR) and Dr D. Sheil (University of Oxford, Plant Sciences Department).

1.5 Collecting permits:

In accordance with existing Government regulations, prior arrangements were made via LIPI to permit staff from each of the international institutions to collect and curate taxonomic collections of plants and animals. In accordance with GoI regulations, all scientists who take collections overseas for identification are to return type specimens and a representative set of identified specimens to the respective partner institutions in Indonesia, in particular the Herbarium Bogoriense and the Zoology Museum. At the time of writing, all specimens have been returned together with their identifications by the overseas institutions.

1.6 Site location and description:

The survey site was located at Pasir Mayang in Jambi Province, Central Sumatra (Annex III; Maps 1,2,3,4). The area includes 900ha of a forest reserve set aside for research by SEAMEO BIOTROP located within the Barito Pacific logging concession. The survey team was based at the BIOTROP research station (with several members also located at the nearby Barito Pacific guest quarters). The area sampled is a mosaic of pristine forest, logged-over secondary forest, softwood plantations, rubber and jungle rubber with secondary mosaics of subsistence gardens and fruit orchards. While the forest is rich in plant species, the dominant tree genera are from the Dipterocarpaceae family. Vegetation is supported by a mixture of relatively low nutrient, gibbsitic, kaolinitic and ferralitic soils over recent alluvium, acidic pumice tuffs, tuffaceous sandstones and carbonaceous mudstones siltstones and sandstones and conglomerates. The area is drained by the Batangahari river that is used to float log rafts down to Kota Jambi. Site locational and physical data including vegetation structure are listed in Annex III, Table 1a. Soil analytical data are contained in Annex III, Table 2.

1.7 Survey design:

1.7.1 General:

To forecast the effects of land-use on biodiversity at the landscape level requires an adequate sample of land-use intensity and land-use types. To set the bounds and system parameters in order to model ecosystem response to human impact requires a specific physical environmental context for land use. With this in mind, the present survey was preceded by a ground reconnaissance of a series of representative land use types (LUTs) in the lowland forested landscapes centred on Pasir Mayang in Jambi Province, Central Sumatra. Although only a limited number of LUTs could be sampled due to logistic constraints, these represented a range of extremes from pristine lowland tropical rain forest through logged-over forest and tree plantations to degraded *Imperata* grassland. Some specialist groups were restricted to only very limited samples (e.g. about 7 x 100m transects for termites alone) in the ten days available for fieldwork. It was therefore necessary to ensure these limited samples were effectively bracketed within a representative subset of vegetation and LUTs.

1.7.2 Gradient-based transects:

For surveys where the purpose is to recover as much information as possible about the distribution of plants and animals it is appropriate to use gradsect sampling (gradient-oriented transects) that rely on the purposive selection of sample sites arranged within a hierarchy of key environmental gradients (Gillison and Brewer, 1985) (Box 1). In the present case, these were rainfall seasonality, soil drainage patterns and time since harvest, or time since 'opening' (e.g. clearing rain forest). For this survey, LUTs were chosen primarily because of the nature of the land use and secondly according to environmental gradients in descending importance. At each LUT a pair of 40x5m strip transects was laid out along the contour where possible. The plot size was pre-determined from assessing results from range of plots elsewhere. As the results show, for most LUTs the 40x5m size is adequate. For very species-rich sites additional plots were added until the cumulative species curve reached a satisfactory (subjective) asymptote. The relatively small 40x5m plot makes it possible to sample animal habitat with a level of sensitivity frequently unobtainable with larger plots. Partly in preparation for this survey, CIFOR had produced a comprehensive digital elevation model (DEM) for Jambi Province compiled from 1:250,000 mapping scale topographic maps. These were supplemented by nested contour sub-maps compiled at 1:50,000 scale for focal survey areas surrounding the BIOTROP research site at Pasir Mayang (Annex III, Maps 1,2)

1.8 Database structure, storage and access:

Data from all collections of plants and animals were cross-referenced with the benchmark site numbers. All data are catalogued (Annex III, Table 15) and are stored on hard disk and as hard copy at CIFOR, as well as being backed up on 100mb Zip diskettes (IOMEGA). The data have been compiled in Microsoft Access and Excel formats. Field data were compiled on-site using the newly developed CIFOR *PFApro* software. This software facilitates direct transfer of data to MSAccess. All data collated from the survey have been distributed to partner institutions, in line with ASB policy.

1.9 Data analyses:

The PATN exploratory data analysis package (Belbin, 1992) was used to detect patterns in the data sets by both classification and ordination (Multi-Dimensional Scaling), using Gower metric and Bray-Curtis measures. Linear correlations between all attribute values were calculated using the Minitab software package. Second order, polynomial regressions were also used to seek improved fits for those attributes with linear 'r' values >0.500 and where indicated by data distribution. These procedures helped identify the most efficient predictors of taxa and functional types and set the scene for further analyses using multiple regression.

Box 1
Gradient-based methods of survey design and data collection

The gradsect method of Gillison and Brewer (1985) employs purposively selected physical environmental gradients as a framework for survey. Sites are located along gradients according to a hierarchy of decreasing physical environmental influence and, usually, spatial scale (e.g. rainfall seasonality, temperature, parent rock type, slope, aspect, soil catena etc). This allows clusters of sites to be located to sample the maximum possible range of environmental variability that is responsible for species distribution and performance. Where the intent is to capture as much environmental variability and species distribution in the area, the method has been found more efficient than surveys based on purely random or purely systematic grid designs (see also Wessels *et al.,* 1998). For plots (of 40 x 5m size) located along gradsects, a rapid survey proforma is used to record site physical variables (georeference by GPS; elevation (m), slope (%), aspect (deg.), soil type (and subsequent physio-chemical analyses), parent rock type, and land-use history. Vegetation structure is recorded according to mean canopy height (m), percent crown cover, litter depth, furcation index, and basal area (m^2 ha^{-1}). All vascular plant species are recorded where possible (Family, Genus Species) and voucher specimens taken for subsequent taxonomic confirmation. Plant Functional Attributes (mainly features that indicate adaptations to environment) are recorded by in-country teams trained in the proforma method. The software package PFAPro developed by CIFOR to facilitate data entry and analysis was used to record data using a standard protocol to ensure compatibility and uniformity of data collection.

1.10 References:

Gillison, A.N. and Brewer, K.R.W. (1985). The use of gradient directed transects or gradsects in natural resource surveys. *Journal of Environmental Management* **20:** 103-127

Wessels, K.J., Van Jaarsveld, A.S., Grimbeek, J.D. and Van der Linde, M.J. (1998). An evaluation of the gradsect biological survey method. *Biodiversity and Conservation* **7:** 1093-1121.