Ecosystem Monitoring and Forest Census Research

19-20 May 2014 at the National Centre for Biological Sciences (NCBS), Bangalore, India

Organised by the Community and Ecosystems Ecology Lab and LEMoN in collaboration with *RAINFOR-GEM* and Univ. Oxford.

Venue: Gandhi Krishi Vigyan Kendra (GKVK) Campus, Bellary Road, Bangalore 560065 (location map).

DAY ONE: Training workshop: *Forest census protocols (RAINFOR-GEM, LEMoN, CTFS-ForestGEO)*

Venue: **Malgova**, 2nd floor, Southern Labs, NCBS

09:00	09:30	Registration outside Malgova
09:30	10:30	Welcome and Introduction to basics of plot establishment and monitoring - Toby Marthews
10:30	11:00	Protocols for IRGA (EGM) measurement of CO2 efflux - Toby Marthews and Sam Moore
11:00	11:30	Tea
11:30	12:00	Protocols for Dendrometer bands - Sam Moore and Toby Marthews
12:00	12:30	Measurement and estimation of Tree height - Toby Marthews
12:30	13:30	Protocols for Coarse woody debris and roots - Sam Moore
13:30	14:15	Lunch
14:15	15:35	Database management and GIS – Dr Suranjan Fernando
15:35	17:00	R workshop & data analysis (Toby Marthews, M.O. Anand, Sandeep Pulla) Please note that no experience of R required, although if using your own laptop for this, it would help to install R first from http://www.R-project.org/ (installation is free).
17:00	17:30	Tea
17:30	18:00	Use of the GEM website
18:00	19:00	Break
19:00		End of workshop

DAY TWO: Conference: *Current directions in Ecosystem Research*

Venue for all talks: **Malgova**, 2nd floor, Southern Labs, NCBS

09:00 09:15 Registration outside Malgova

09:15 09:20 **Dr. Mahesh Sankaran, NCBS, Bangalore**
Opening remarks

09:20 09:40 **Prof. Yadvinder Malhi, University of Oxford**
Introduction to the full carbon cycle of ecosystems

Much forest ecosystem monitoring is based on the census of tree diameters and species identification. While the information obtained from such censuses is very valuable, it only gives a partial picture of the full carbon budget of the ecosystem. I introduce a more comprehensive approach to understanding ecosystem function that places tree growth in the context of photosynthesis, productivity, growth and mortality. Such an approach opens a new perspective on several questions and approaches in ecosystem ecology and the response of ecosystems to climate change and disturbance.

09:40 10:00 **Dr Sam Moore, University of Oxford**
Carbon cycling and allocation in West and Central Africa: An overview

The Global Ecosystems Monitoring (GEM) network reached Africa in 2011/12 and is currently focused in two countries, Ghana (West Africa) and Gabon (Central Africa), where we have strong collaborative partnerships with the Forestry Research Institute of Ghana (FORIG) and L'Agence Nationale des Parcs Nationaux (ANPN), respectively. As GEM grows, more and more carbon cycling plots are being established, not just in Africa (e.g. Ethiopia, Uganda), but all over the world.

Ghana and Gabon were selected as contrasting samples of the West African (Guinean) and Congo Basin forests and we have three study sites in each country. Within each site, multiple one hectare plots (20 in total) were established in which to conduct long-term studies of above- and belowground productivity, autotrophic and heterotrophic respiration and microclimate. In both countries, our sites encompass contrasting wet and dry plots as well as a logging chronosequence in Ghana where six plots are being monitored throughout the logging process.

In this short talk I will present an overview of our progress to date and some preliminary data from the plots where we are just reaching our first year of complete NPP datasets. These data will complement our ongoing 17 research plots across Amazonia and 7 plots in Malaysia. All plots follow the same GEM-RAINFOR protocols and methodologies, allowing pan-tropical forest carbon cycling to be compared for the first time.

10:00 10:20 **Dr Jayashree Ratnam, NCBS Bangalore**

Building a network of forest monitoring plots in India

Earth's tropical and sub-tropical forests play a major role in regulating atmospheric carbon dioxide, and are perhaps our single largest buffer against runaway warming. Given this scenario, it is not surprising that documenting and understanding the ecology of earth's tropical forests has become one of the most urgent research priorities for ecosystem ecologists today. Responding to this need, several tropical countries across the globe have established impressive networks of forest monitoring plots, which are now yielding critical insights into the dynamics of African, South-American and south-east Asian forest systems.

India is a country with relatively high forest cover of and a wealth of research relating to the biodiversity of Indian forests. However, there are few long-term forest monitoring sites where the data are collected to match international protocols or to empirically quantify the carbon dynamics of these important ecosystems. At present, much remains unknown about the role of Indian forests in regulating regional and global climate, as well as their potential responses to future changes in climate. India needs a network of long-term monitoring plots that encompasses its key forest types across a range of climates to answer such critical questions.

In this brief presentation, I will describe our group's efforts to initiate such a network of monitoring (LEMoN-INDIA), using a bottom-up grassroots approach. I will describe our approach to this problem, the choice of our sites in southern India, the operational challenges that we face, and our efforts to "grow" the network in an open collaborative model.

10:20 10:40 **Dr Toby Marthews, University of Oxford**

RAINFOR-GEM in Malaysia - the SAFE Project and Disturbance Gradients

Tropical forests play a major role in the global carbon cycle, both as probable sinks of atmospheric carbon dioxide (CO2) in intact forests and as sources of atmospheric greenhouse gases through biomass burning, decomposition and deforestation. These forests also harbour over one half of global biodiversity and a quarter of all the biomass and soil carbon found on land. Since 2008, the RAINFOR-GEM network of 'intensive' carbon monitoring plots has been measuring a comprehensive spectrum of ecosystem components at permanent census areas in all three main tropical zones. As part of this research effort, seven RAINFOR-GEM hectare plots were installed in the SAFE Experimental Area and Maliau Basin (Sabah, Malaysia) during 2011 and the first two tree censuses carried out in 2011 and 2012.

The RAINFOR-GEM protocols involve permanent tagging and numbering of tree stems and the installation of rhizotrons, in-growth cores, litter traps, dendrometers and CO2 efflux collars. In the context of the SAFE project in Sabah, these protocols have been applied not only in intact tropical forest areas but also in several logged forest locations where timber extraction and conversion to oil palm is ongoing. Quantifying the carbon budget of these ecosystems has led to a globally unique data set on the carbon costs of oil palm conversion in this area of SE Asia. In this short talk I summarise the initiation of these unique plots in Sabah and describe the implications of these measurements for carbon sequestration along a tropical forest

disturbance gradient and within the context of the expanding oil palm sector in Malaysia and current developments in international forest monitoring programmes.

10:40 11:00 Tea

11:00 11:20 **Prof. Priya Davidar, Pondicherry University**

The distributional patterns of evergreen trees of the Western Ghats is associated with climate

We assessed the effects of latitude, altitude and climate on the alpha diversity, beta diversity and rarity of rain forest trees (≥ 10 cm dbh) in the Western Ghats of India. We used data from small plot inventories concentrated in three regions: the southern Western Ghats, the Central Western Ghats and the Nilgiri mountains. Rainfall seasonality increased from the south to the north along the latitudinal gradient, and annual rainfall was highest in the Central Western Ghats. Tree alpha diversity increased with decreasing seasonality and decreased with altitude. Seasonality also influenced dominance and rarity. Beta diversity was highest along the latitudinal axis, and along the east-west axis in the Central Western Ghats which has a strong rainfall gradient. Rarer trees were shorter understory species, whereas common and widespread species were taller trees. Climate, particularly seasonality appears to be the primary driver of diversity and distribution among rain forest trees of the Western Ghats.

11:20 11:40 **Anand Osuri, NCBS Bangalore**

Understanding the effects of fragmentation on tree communities and carbon storage in a tropical rainforest landscape: a functional traits approach

Habitat fragmentation affects several ecological processes and causes marked shifts in the structure and functioning of ecosystems. Fragmentation is one of the most pervasive forms of anthropogenic disturbance to forests across the tropics, and is of global concern in the context of biodiversity conservation and ecosystem services. In this talk, I will investigate the effects of tropical rainforest fragmentation on tree communities and aboveground carbon storage in the Western Ghats. First, I will compare aboveground carbon storage between contiguous and fragmented rainforests, and explore the structural and compositional shifts which contribute to differences in carbon storage at present. Next I will utilize an analysis of plant functional traits to will evaluate the trait-fragmentation relationships and relationships among traits which link forest fragmentation, tree community turnover and carbon storage potential. From these results, I will draw insights into the likely processes driving the observed shifts in tree communities and carbon storage. Finally, I will discuss these findings in the broader context of tropical forest responses to anthropogenic disturbances.

11:40 12:00 **Prof. Nimal Gunatilleke, University of Peradeniya**

Sinharaja Forest Dynamics Plot of Sri Lanka – A member of the ForestGEO-CTFS Network Program for Long-Term and Large-Scale Forest Ecological Research

Monitoring long-term responses and detecting trends in forest communities due to environmental changes require verifiable time series analyses of stand dynamics conducted using standardized methodology across multiple study sites. The Forest Global Earth Observatory of the Center for Tropical Forest Science (ForestGeo-CTFS) network established for

monitoring growth and survival of saplings to adult trees in excess of 50 forest dynamics plots over a period of twenty or more years and spread across tropical and temperate regions of both paleotropics and neotropics has significant potential to contribute to the global change science.

The 25 ha Forest Dynamics Plot in Sinharaja mixed dipterocarp forest located in aseasonal SW lowlands in Sri Lanka is a partner in this CTFS network. Since 1994, four censuses, each with a five-year census interval, have been carried out in Sinharaja plot which represents relatively low species diversity but with higher endemicity compared to some of the South-east Asian, Central African and Amazonian rain forest counterparts. This could be attributed to island biogeographic phenomena leading to ecological and geographic isolation from areas with similar climate over its geo-evolutionary history.

Habitat heterogeneity resulting from topographic structuring within the plot appears to be an important driver of spatial differentiation and may contribute to strong species-habitat association leading to stabilizing species coexistence, especially in heterogeneous environments. However, it has explained only a part of the variability in species composition in the plot. Therefore, other factors such as soil moisture, biota and nutrients, spatial and temporal light regime, seed dispersal etc. may capture more of the species variation in Sinharaja plot.

Time series analyses of long-term forest dynamics in over 50 plots distributed in 23 countries and censusing over 4.5 million trees belonging to 8,500 species will go a long way in increasing our understanding on the maintenance of species diversity and managing forest resources in a sustainable manner in a rapidly changing global climate.

12:00 12:20 **Rutuja Chitra-Tarak, IISc Bangalore**

Beware trees shrink: Tree diameter growth estimation in a seasonally tropical forest must account for reversible shrinkage.

Measuring stem diameter change remains the most common method to estimate tree growth, in forestry and climate change studies. Besides addition of wood, trunk diameter also changes due to swellings and shrinkages with changing bole moisture storage. However bias due to these changes remains hitherto unknown although estimates of uncertainty are crucial in modeling forest growth and C sequestration. Especially in systems with high environmental variability - such as the seasonally dry tropical forests (SDTF) – where growth component is relatively small growth biases due to water flux are likely to be high. We evaluate & find substantial water flux related biases in growth estimates of a seasonally dry tropical forest in Southern India. We also find that in annual growth estimates wet season bias is significantly higher than dry season bias and suggest that dry season should be the preferred timing for annual growth measurement.

12:20 13:20 **Dr Handanakere S. Dattaraja, IISc Bangalore**

Dynamics of a seasonally dry tropical forest of Mudumalai, southern India

There has been much interest in ecological processes, including maintenance of species diversity, turnover rates, growth rates and carbon fluxes, in tropical forests, especially in the light of climate change. Tropical forests encompass a wide range of climatic regimes from semi-arid woodland to a-seasonal rainforests. Comparative studies of tropical forest types have generally used data from plots in different regions of the globe. We have been studying the comparative structure and dynamics of a tropical forest in

a series of 19 one-ha permanent plots established during 1993-94 along a strong east-west rainfall gradient (c.600-1800 mm annual average) within a distance of <50 km in Mudumalai, southern India. Forest types vary correspondingly from dry thorn forest through dry deciduous and moist deciduous forest to semi-evergreen forest. All woody stems >1cm DBH were tagged, identified and mapped during the first enumeration; our plots recorded 21565 individuals from 198 species of 56 families of angiosperms. The plots have been subsequently monitored for mortality, recruitment, and diameter growth once every four years (1998, 2003, 2007 and 2012). During the 18-year study period, Mudumalai experienced variability in abiotic and biotic factors including droughts (e.g. 2002-2003), annual fires, and weed proliferation. Preliminary results suggest a decline in the population of woody plants, especially following the 2002-2003 drought period, that is reflected in a concomitant decrease in species diversity. Other salient results and their implications are discussed.

13:20 13:40 Lunch

13:40 14:00 **Dr Ghazala Shahabuddin, Ambedkar University**

Ecological Outcomes of Community-based Conservation in Western Himalayan Forests

The speaker will share results from recent research on the role of the van panchayats (village-based forest councils) in sustainably managing mid-altitudinal oak-pine forests (1500-2500 m asl) of the Western Himalayas. Preliminary study of forest indicators related to vegetation structure, diversity and regeneration of dominant tree species, as well as resource utilization patterns, has been carried out in a cluster of six forest management units from 2011-2013. Forest indicators suggest intense extractive pressure due to tree-lopping, grazing, fodder-grass collection, leaf-litter extraction and use of fire which may not be sustainable. Study of size-class distributions of pine, oak and their associates, indicate stalling of natural succession of pioneer pine into multi-species hardwood forest, and 'invasion' by pine into oak stands, encouraged by government plantations and local management pressures. The importance of long-term monitoring for understanding vegetation dynamics due to prevalent extraction pressures, will be discussed.

14:20 14:40 **Dr T. R. Shankar Raman & Dr Divya Mudappa, Nature Conservation Foundation, India**

Tropical rainforest plant research in a fragmented plantation landscape, Anamalai Hills: An overview

We have studied tropical rainforest fragmentation and restoration for nearly two decades in the Valparai plateau (220 sq. km) and Anamalai Tiger Reserve, Anamalai Hills, southern Western Ghats. Our research has addressed changes in forest structure and tree species richness in fragments ranging in size from 1 ha to around 2600 ha, occurrence and distribution of invasive alien species in forest fragments and along roads, and community composition of trees, lianas, and understorey plants in forest fragments and relatively undisturbed forests. This research has complemented and informed a rainforest restoration programme, implemented since 2001 in 45 sites across 15 fragments, where 26,500 seedlings of 160 native tree and liana species were planted in 50 ha of restoration sites and 13,500 seedlings of 60 native species planted out as shade trees in coffee, cardamom, vanilla, and tea plantations. Other researchers have also studied tree phenology, floristics, and plant -- animal interactions in relatively undisturbed forests within the Anamalai Tiger Reserve. Long-term monitoring has been patchy and opportunistic, based on studies with different objectives that happened to use similar methods in the same sites. There remains considerable scope for research to track long-term effects of forest fragmentation, restoration, and climate change.

14:40 15:00 **Sandeep Pulla, IISc Bangalore**

Tree abiotic niche differentiation in a tropical forest

Theory predicts that species occupying identical niches cannot coexist. Yet, high levels of alpha diversity are observed in tropical forest trees, all of which apparently require the same set of resources. Evidence that plants in natural communities are segregated along spatial gradients of light, water, and nutrients is growing, but far from conclusive. Furthermore, environmental heterogeneity resulting from, say, interannual rainfall variability, creates opportunities for temporal niches. I discuss the evidence for tree niche differentiation along resource gradients in space and time using long-term data from a seasonally dry tropical forest in southern India.

15:00 17:30 **Discussion Session with Tea**

17:30 18:30 **Prof. Yadvinder Malhi, University of Oxford**

PUBLIC TALK: The growth, biomass and functioning of tropical forests: new insights from a whole carbon budget perspective

What determines the productivity, growth and biomass of tropical forests, and how they are responding to global atmospheric change? To date empirical studies of this question have focused on either long term monitoring plots or remote sensing. I present new results from a network of high intensity tropical forest monitoring plots across the tropics, the Global Ecosystems Monitoring (GEM) network, and use these results to explore some classic questions in tropical forest ecology. I show that asking questions from a whole carbon budget perspective changes the questions we ask and can produce some surprising answers. Why do tropical trees grow more slowly in the dry season? Why do tropical dry forests have lower biomass than wet forests? Why do tropical montane forests grow more slowly than lowland rainforests? To date much ecosystem modeling of tropical biomes under climate change has focused on photosynthesis and growth. I argue that it is equally important to understand the determinants of tree mortality rates, tree stature and carbon allocation to understand the carbon cycle of the tropical biome and how it will respond to local and global drivers of change.