CTFS Network-Wide Symposium

The Center for Tropical Forest Science
of the Smithsonian Tropical Research Institute

and the

Taiwan Forestry Research Institute

present

Forests in Flux:
Findings from the Forest Dynamics Plot Network

August 16 – 17, 2004
Taiwan Forestry Research Institute
Taipei, Taiwan

Symposium Booklet of Abstracts

This symposium is supported by CTFS, TFRI, STRI, the National Science Council of Taiwan, and the U.S. National Science Foundation.

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Agenda

- *August 16th*: 10:00 a.m. – 5:30 p.m., followed by an evening reception which is tentatively scheduled to begin at 7:30 p.m.
- *August 17th*: 8:30 a.m. – 1:45 p.m.

Schedule of symposium talks

(International Conference Hall – 12th floor of TFRI)

Monday, August 16, 2004

Time	Speaker	Presentation Title
10:00 – 10:30 a.m.	REGISTRATION (Poster set-up) (Coffee, tea, and snacks available)	
10:30 – 10:40 a.m.	**Hen-Biau King** *Taiwan Forestry Research Institute*	Introductory and Welcome Remarks
10:45 – 11:15 a.m.	**Elizabeth Losos** *Smithsonian Tropical Research Institute*	Forest Dynamics Research in Flux
11:20 – 12:15 p.m.	**Stephen Hubbell** *University of Georgia*	The BCI Forest Dynamics Project: Past, Present, and Future
12:20 – 1:20 p.m.	LUNCH and POSTER SESSION (Traditional Taiwanese Box Lunches)	
1:25 – 1:45 p.m.	**Renato Valencia** *Pontifica Univ. Catolica del Ecuador*	Tree Species Distributions at Local and Geographic Scales for Species Found in the Yasuní Forest Dynamics Plot in Ecuadorian Amazon
1:50 – 2:10 p.m.	**C. V. S. Gunatilleke** *University of Peradeniya*	Species-Habitat Associations in a Forest Dynamics Plot in Sinharaja World Heritage Site, Sri Lanka
2:15 – 2:35 p.m.	**Liza Comita** *University of Georgia*	Seedling Habitat Associations in a Neotropical Tree Community
2:40 – 3:00 p.m.	**Jérôme Chave** *CNRS - Université Paul Sabatier Toulouse*	Tropical Carbon Cycle: Recent Advances
3:05 – 3:25 p.m.	**Kuo-chuan Lin** *Taiwan Forestry Research Institute*	Root Biomass and Nutrient Distribution of Tree Species in a Subtropical Forest in Taiwan
3:30 – 3:50 p.m.	COFFEE BREAK (POSTER SESSION)	

Monday, August 16, 2004 cont'd

Time	Speaker	Presentation Title
3:50 – 4:10 p.m.	**Yu-Yun Chen** *University of Georgia*	Two Unusual Mast Fruiting Events in a Lowland Dipterocarp Forest
4:15 – 4:35 p.m.	**Andrew Jones** *University of Georgia*	Direct Measurement of Seed Dispersal and Fecundity in the Neotropical Tree, *Jacaranda copia*
4:40 – 5:00 p.m.	**Lee Ling-Ling** *National Taiwan University*	Seed Dispersal by Taiwan Macaques at Fushan Experimental Forest
5:05 – 5:15 p.m.	**Ira Rubinoff** *Smithsonian Tropical Research Institute*	Closing Remarks
7:30 – 9:30 p.m.	GALA RECEPTION (1st floor of Formosa International Hotel , No. 3, Lane 39, Sec. 2, Chung Shan N. Rd., Taipei.)	

Tuesday, August 17, 2004

Time	Speaker	Presentation Title
8:30 – 8:45 a.m.	MORNING COFFEE	
8:45 – 9:05 a.m.	**Richard Condit** *Smithsonian Tropical Research Institute*	Tree Populations in Tropical Forest: Stability and Rare Species Rescue in Large-scale Plots from all Continents
9:10 – 9:30 a.m.	**James V. LaFrankie** *Smithsonian Tropical Research Institute*	Ten Years of Forest Dynamics in a Fragment in Bukit Timah, Singapore
9:35 – 9:55 a.m.	**Teng-Chiu Lin** *National Changhua University of Education*	Typhoon Disturbance and Forest Dynamics in a Subtropical Rainforest: Does the Response of New World Forests Characterize the Response of Old World Forests?
10:00 – 10:20 a.m.	**Duncan Thomas** *Smithsonian Tropical Research Institute*	Biodiversity and Forest Dynamics in Central Africa
10:25 – 10:40 a.m.	COFFEE BREAK	

Tuesday, August 17, 2004 cont'd

Time	Speaker	Presentation Title
10:45 – 11:05 a.m.	**H. S. Suresh** *Centre for Ecological Sciences* *Indian Institute of Science*	Patterns of Mortality, Recruitment and Population Change (1988 - 2000) in a Tropical Dry Deciduous Forest at Mudumalai, Southern India
11:10 – 11:30 a.m.	**Cheryl Nath** *Centre for Ecological Sciences* *Indian Institute of Science*	Tree Diameter Growth Patterns in the Dry Deciduous Forest of Mudumalai, Southern India
11:35 – 11:55 p.m.	**Christopher Wills** *University of California - San Diego*	Positive Effects of Diversity on Growth and Recruitment in Tropical Rainforests
12:00 – 12:20 p.m.	**Yue-Joe Hsia** *National Donghwa University*	Evaporation at Two Mountain Forests in Taiwan
12:25 – 12:35 p.m.	**Hen-Biau King** *Taiwan Forestry Research Institute*	Closing Remarks
12:35 – 1:45 p.m.	LUNCH and POSTER SESSION	

Poster Session

(International Conference Hall Lobby – 12th floor of TFRI)

Presenter	Poster Title
Stephanie Ann Bohlman & **Richard Grotefendt**	Large Tree Species Composition, Sun-exposed Crown Area and Growth on Barro Colorado Island, Panama
Chia-Hao Chang-Yang & **Chang-Fu Hsieh**	The Seed Rain in a Subtropical Rain Forest, Fushan, Northern Taiwan
George Chuyong	Flowering and Fruiting Phenology at a Strongly Seasonal Tropical Forest at Korup, Cameroon
Leonardo Co *et al.*	Palanan Forest Dynamics Plot: Floristic Diversity and Stand Structure of a Lowland Evergreen Forest in NE Luzon, Philippines
H. S. Dattaraja	Plant Species Diversity of a Dry Tropical Forest, Mudumalai, Southern India
Alexandre A. de Oliveira	A New Forest Dynamics Plot in the Central Amazon: Topography and Richness Estimates
Tamara Heartsill Scalley *et al.*	Characterization of Tree Species in the Riparian Zones of the Luquillo Forest Dynamics Plot (LFDP)
Robert John *et al.*	Soil-borne Resources and the Distribution of Tree-species in Tropical Forests: A Study from BCI, Panama
Hsuan-Te Lee & **Fong-Long Feng**	Combining Ecological Site Quality with Potential Growth in a Productivity Model
Chia-Ling Leu & **Chang-Fu Hsieh**	Short-term Dynamics of Tree Seedlings in a Subtropical Rain Forest, Fushan, Northern Taiwan
May-Ling Liao & **Hsing-Juh Lin**	Budgeting Fluxes of Coarse Particulate Organic Matter in the Mountain Streams of Wulin Area
Jordan Macy	Nitrous Oxide Fluxes in Two Different Subtropical Rainforests
Margaret Metz	Seedling Dynamics in Yasuní National Park, Ecuador: Preliminary Results

Poster Session cont'd

(International Conference Hall Lobby – 12th floor of TFRI)

Presenter	Poster Title
Xiangcheng Mi *et al.*	Spatial Niche Analysis of *Quercus liaotungensis* in a Temperate Forest with 2D-Wavelet Analysis
Sabrina Russo *et al.*	Soil-related Performance Variation and Species' Distribution Patterns in a Bornean Rain Forest
Sheng-Chieh Wu & **Chang-Fu Hsieh**	Community Structure and Spatial Pattern of Major Tree Species in an Old-Growth Mixed Temperate Forest at the Cinsbu Area, North Taiwan
Kuoh-Cheng Yang *et al.*	Permanent-plot Study of the Temperate Evergreen Broad-leaved Forest in Upstream Region of Nantzushien Creek in Central Taiwan
Shu-Fen Yu *et al.*	Temporal and Spatial Changes in Abundance and Composition of Epilithic Periphyton in the Mountain Stream of Wulin Area, Central Taiwan

Site List

CTFS Forest Dynamics Plot Programs

Center for Tropical Forest Science Programs	Collaborating Institutions	Year Initiated & Censuses Completed	Plot Size	Altitude	Rainfall & Dry Season	Species & Trees
LATIN AMERICA						
Barro Colorado Island Nature Monument, Panamá	CTFS / Smithsonian Tropical Research Institute, University of Georgia (USA)	1980 5cen. (2000)	50 ha	120-160 m	2551 mm 3 mos.	300 spp 213,800 trees
Luquillo Experimental Forest, Puerto Rico	University of Puerto Rico (USA), U.S. Forest Service, STRI	1988 3cen. (2001)	16 ha	333-428 m	3548 mm 0 mo.	138 spp 67,100 trees
Yasuní National Park, Ecuador	Pontificia Universidad Católica del Ecuador, University of Aarhus (Denmark), STRI	1995 2cen. (2004)	50 ha	215-245 m	3081 mm 0 mo.	1104 spp 152,400 trees (25 ha)
La Planada Nature Reserve, Colombia	Instituto de Investigación de Recursos Biológicos "Alexander von Humboldt", STRI	1996 1cen. (1998)	25 ha	1718-1844 m	4087 mm 0 mo.	228 spp. 115,100 trees
Biological Dynamics of Forest Fragments, Manaus, Brazil	Brazilian Institute for Research in the Amazon (INPA)	Future Site Cen. On-going	50 ha.	40-80m	2600mm 5mo.	———
ASIA						
Pasoh Forest Reserve, Peninsular Malaysia	Forest Research Institute Malaysia, National Institute of Environmental Studies (Japan), Arnold Arboretum – Harvard University (USA), STRI	1986 4cen. (2001)	50 ha	70-90 m	1788 mm 1 mo.	816 spp 305,900 trees
Mudumalai Wildlife Sanctuary, India	Center for Ecological Sciences of the Indian Institute of Science, STRI	1988 5cen. (2004)	50 ha	980-1120 m	1206 mm 6 mos.	71 spp 18,000 trees
Huai Kha Khaeng Wildlife Sanctuary, Thailand	Royal Thai Forest Department, Kasetsart and Mahidol Universities (Thailand), Arnold Arboretum – Harvard University (USA), STRI	1993 3cen. (2004)	50 ha	549-638 m	1476 mm 6 mos.	251 spp 72,500 trees
Sinharaja World Heritage Site, Sri Lanka	University of Peradeniya (Sri Lanka), Sri Lanka Department of Forestry, Arnold Arboretum – Harvard and Yale Universities (USA) , STRI	1993 2cen. (2002)	25 ha	424-575 m	5074 mm 0 mo.	204 spp 193,400 trees
Lambir Hills National Park, Sarawak, Malaysia	Sarawak Forest Department, Arnold Arboretum – Harvard University (USA), Osaka City, Ehime, & Kyoto Universities (Japan), STRI	1990 3cen. (2003)	52 ha	104-244 m	2664 mm 0 mo.	1182 spp 359,600 trees
Bukit Timah Nature Reserve, Singapore	National Institute of Education / Nanyang Technological University (Singapore), Singapore National Parks Board, Arnold Arboretum – Harvard University, STRI	1993 4cen. (2003)	2 ha	150 m	2473 mm 0 mo.	329 spp 11,900 trees
Palanan Wilderness Area, Philippines	University of the Philippines, Isabela State University College of Forestry (Philippines), Conservation International, PLAN International, Arnold Arboretum – Harvard University, STRI	1994 2cen. (2004)	16 ha	100-180 m	3218 mm 4 mo.	335 spp 66,000 trees (8 ha)
Doi Inthanon National Park, Thailand	Royal Thai Forest Department, Osaka City, Kyoto, Maejo, and Utsunomiya Universities (Japan), Kasetsart University (Thailand), Chiba Natural History Museum and Institute (Japan), STRI	1997 1cen. (2000)	15 ha	1660-1740 m	1867 mm 6 mos.	162 spp 73,700 trees
Fushan Nature Reserve, Taiwan	Taiwan Forestry Research Institute, Tunghai University (Taiwan), STRI	2002 Cen. On-going	25 ha	650-733 m	4067 mm 0 mo.	———
Nanjenshan Nature Reserve, Taiwan	Tunghai University (Taiwan), STRI	1989 2cen. (1997)	6 ha	300-340 m	3582 mm 0 mo.	125 spp 36,400 trees
Khao Chong Wildlife Refuge, Thailand	Royal Thai Forest Department, National Institute of Environmental Studies (Japan), Arnold Arboretum – Harvard University (USA), STRI	1998 1cen. (2003)	24 ha	50-300m	2700 mm 2-3 mos.	602 spp. 120,000 trees
AFRICA						
Ituri Forest/Okapi Wildlife Reserve, Democratic Republic of Congo	Centre de Formation et de Recherche en Conservation Forestiere (D. R. Congo), Wildlife Conservation Society (USA), STRI	1994 2cen. (2002)	40 ha	700-850 m	1674 mm 3-4 mos.	446 spp 288,000 trees
Korup National Park, Cameroon	BioResources Development and Conservation Programme - Cameroon, Oregon State University (USA), International Cooperative Biodiversity Group, STRI	1996 1cen. (1999)	50 ha	150-240 m	5272 mm 3 mos.	494 spp 329,000 trees

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Oral Presentations

Abstracts

(in the order they appear)

Monday, August 16, 2004

Forest Dynamics Research in Flux

Elizabeth Losos

Smithsonian Tropical Research Institute, USA

The Center for Tropical Forest Science of the Smithsonian Tropical Research Institute oversees a network of 17 large-scale (typically 50 ha), standardized Forest Dynamics Plots (FDP) across Africa, Asia, and Latin America. All trees greater than 1 cm dbh are measured, identified, mapped, and recensused periodically. At present, CTFS plot programs are monitoring more than 3 million trees of 6000 species.

Due to their intensive sampling regime, large size, spatial dimension, and global standardization, the Forest Dynamics Plots have both unique advantages and disadvantages. This talk will provide an overview of all of the Forest Dynamics Plots in the CTFS network as well as detail some of the unique findings of the plots in terms of global patterns of species diversity and floristics.

In the past three years, CTFS has coordinated workshops to support the analysis of plot data and the training of scientists from around the globe, especially from those countries where Forest Dynamics Plots are located. During these workshops CTFS researchers have utilized the statistical freeware program "R", to evaluate habitat associations, growth, recruitment, and mortality within the plot network. This talk will provide examples of results from previous workshops.

The BCI Forest Dynamics Project: Past, Present, and Future

Stephen Hubbell

University of Georgia, USA

Next year marks the 25th anniversary of the BCI Forest Dynamics Project, a year to take stock on what we have learned so far, both what progress and what mistakes we made, and where the findings suggest our research efforts should go in the future. This talk anticipates this discussion, and also attempts to set the BCI project in a larger theoretical context in community ecology. In particular, I will discuss the current status of natural theory, and discuss new developments in the theory that give it greater realism and generality.

Tree Species Distributions at Local and Geographic Scales for Species Found in the Yasuní Forest Dynamics Plot in Ecuadorian Amazon

Renato Valencia[1], Richard Condit[2], Gorky Villa[1], Elizabeth Losos[2], Consuelo Hernández[1], Gonzalo Rivas[1]

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We analyze the geographic and local distribution of 750 species 400 morphospecies of trees ≥ 10 mm in diameter found in a 25-ha plot of the Yasuni Forest Dynamics Plot. The plot is located in a relatively well drained terra firme forest. We explore: (1) Are there many endemic species to the Ecuadorian Amazon (70.000 km2)? (2) What is the geographic range of non-endemic species: Are they widely distributed or mostly restricted to a certain area of the western Amazonia? (3) Are the locally rare species (<1 individual per ha) widely distributed? and (3) what is the proportion of the species and morphospecies that grow in inundated forests around the 25-ha plot? We compare our 750 species with a dataset of species based on checklists and plots, and information provided by the CTFS via the internet (http://ctfs.si.edu/neotropicaltree/namecheck.) The information includes checklists of entire countries like Panama, Surinam, and regions like the tropical rain forest in the southern most part of Mexico, the Central Amazonia in Brasil, the moist forests of Northern Bolivia, the South Eastern Colombia and the Northeast part of Peru. At the time of abstract submission, the preliminary analysis is still underway, but an obvious result is that almost all the species are distributed outside the Ecuadorian Amazonia.

Species-Habitat Associations in a Forest Dynamics Plot in Sinharaja World Heritage Site, Sri Lanka

C.V.S. Gunatilleke[1], I.A.U.N. Gunatilleke [1], Shameema Esufali[1], Kyle Harms[2],
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Based on elevation, slope and convexity eight habitats (steep and less-steep spurs and steep and less-steep gullies, all at either the lower or upper elevations) were differentiated in a 25-ha forest dynamics plot in the Sinharaja rain forest in Sri Lanka. The structure, floristics and spatial distribution patterns of species (stems $\geq$ 1-cm dbh) among these habitats were examined.

Mean density was significantly greater in (i) high elevation spurs than in low, less-steep gullies, (ii) within each elevation range on spurs, and (iii) each high elevation habitat than in the corresponding low elevation habitats. Basal area reflected similar trends. Species richness and Fisher's alpha were lower in the high elevation habitats, than in the low elevation habitats. These differences appear to be related to the density of the dominant species in the high (*Humboldtia laurifolia* with 1,798 ind./ha) and low (*Psychotria nigra* with only 486 ind./ha) elevation habitats.

Torus-translation tests showed, (i) 94 positive and 81 negative associations with at least one habitat type. Of the significantly positive associations in the upper elevations 74% of 66 were with spurs; in the lower elevations 83% of 109 were with the gullies; (ii) 99 species (79%) showed significant associations to one or more habitats. 80% of the 41 abundant species ($\geq$800 ind./25ha), 83% of the 58 less abundant species (<800 to $\geq$100 ind./25ha), over 84% of the canopy/subcanopy species and 60-86% among the understory woody species were positively associated with habitats.

Habitat specialization of the sympatric *Shorea, Mesua* and *Syzygium* species along the topographic catena in the Sinharaja plot is consistent with previous findings on the differentiation of ecophysiological and morphological attributes in seedlings in similar topography. These studies suggest that topographic and associated edaphic variations and canopy disturbances of varying intensity, type and extent along the catenal landscape may contribute to habitat partitioning in Sinharaja.

Seedling Habitat Associations in a Neotropical Tree Community

Liza Comita

University of Georgia, USA

Niches differentiation among species has been proposed to explain how high diversity may be maintained in tropical tree communities. Traditionally, studies of niche differences among tropical tree species have focused on variation in understory light levels. However, associations among tree species and topographically defined habitats have been observed in tropical forests worldwide and suggest that some species may specialize on local soil moisture levels, which are known to vary with topography. However, since most studies of habitat associations have focused only on adult distributions, it remains unclear at what life stage these associations begin to form.

We conducted a community-wide census of seedlings and small saplings in the 50-ha Forest Dynamics Plot (FDP) on Barro Colorado Island (BCI), Panama. All woody plants > 20cm in height and < l cm dbh were mapped, tagged, measured, and identified in twenty thousand uniformly distributed 1-m2 plots. Using this data on the spatial distributions of seedlings, we tested for associations between species and 5 different habitat types (slope, high plateau, low plateau, swamp and stream). We then compared species associations at the seedling stage with adult and sapling habitat associations in the BCI 50-ha FDP using the torus translation method (Harms et al 2001).

Seedlings and adults often have similar distributions due to limited seed dispersal making it difficult to determine whether seedling habitat associations are due to local dispersal or to higher survival in preferred habitats. Therefore, we also used previously calculated, species-specific dispersal curves to predict seed rain into different habitat types. We then compared the predicted density of seeds with actual densities of seedlings in various habitat types. Comparisons of species' associations at various life stages allow us to determine when habitat associations are forming and offer insight into the mechanisms behind observed species' habitat associations.

Tropical Carbon Cycle: Recent Advances

Jérôme Chave

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Climate change may alter the functioning of old-growth tropical forests, resulting in an accelerated tree growth and dynamics, and in an overall increase in biomass stocking by this biome. This hypothesis was set forth in the 1980s, and since then it has generated much research. Yet, a clear-cut demonstration of this effect has been hampered by the lack of reliable long-term field data in the tropics, and also by methodological issues. Current evidence suggests that forest biomass is increasing in the Amazon, and that this effect is more marked in the rich-soil regions of the Western Amazon than in the poor soils of the Central and Eastern Amazon. However, studies in the BCI forest (Central Panama) and in the Pasoh forest (peninsular Malaysia) do not confirm this pattern of biomass increase over the past few decades. If climate change is really driving a change in old-growth tropical forest functioning, an increase in biomass should be consistently measured across the tropics. I will discuss the methodological limitations associated with these predictions, and new directions for testing this hypothesis with long-term forest plots.

Root Biomass and Nutrient Distribution of Tree Species in a Subtropical Forest in Taiwan

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The biomass and nutrient distribution of roots for tree species in a subtropical roadleaf nature forest within the Fushan Experimental Forest in northeastern Taiwan, one of the TERN sites, were studied. Eight sample trees with wide range of dbh were harvested to estimate belowground biomass. Mean biomass of necromass, fine roots, and coarse roots were 0.2, 4.1, and 70.2 kg/tree, respectively. For a single tree the root biomass was 24% (range 16-46 %) of aboveground biomass, or 19% (range 14-31%) of total tree biomass. The total root biomass of trees was highly significantly related to dbh ($p < 0.01$). The root biomass of trees ranged from 44.5 to 69.9 Mg/ha in the stands with stem basal area ranged 24.2-44.6 m2/ha, whereas the aboveground biomass of trees ranged from 138.4 to 232.9 Mg/ha. The total nutrient pools of tree roots ranged from 352 to 579 kg/ha for N, 18 to 30 kg/ha for P, 73 to 116 kg/ha for K, 88 to 138 kg/ha for Ca, and 35 to 58 kg/ha for Mg. In the whole trees 44.6-45.1% of N, 39.8-40.3% of P, 20.1-20.9% of K, 14.9-15.5% of Ca, and 26.2-26.8% of Mg were stored in the roots. Finally, the nutrient distribution in the strata of the whole forest ecosystem was discussed.

Two Unusual Mast Fruiting Events in a Lowland Dipterocarp Forest

Yu-Yun Chen

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Abstract Not Available

Direct Measurement of Seed Dispersal and Fecundity in the Neotropical Tree, *Jacaranda copia*

Andrew Jones

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We determined patterns of seed dispersal by wind in the gap-dependent tropical tree *Jacaranda copaia* measured by genotyping maternal tissue attached to dispersed seeds. We captured seeds in a large seed trap array for two years across 84 ha of tropical forest on Barro Colorado Island, Panama. Genetic analysis reveals that a large proportion of seeds, greater than 20% each year, moved distances greater than 100m. Mean dispersal distances differ between years due to differences in wind profiles and the number of seeds moving long distances increased due to changes in the dispersal kernel and increases in fecundity and seed production. We fit a variety of dispersal kernels to our directly measured data and found that a mixture distribution, consisting of a Gaussian shaped curve with a negative exponential tail, best fit the observed number of dispersed seeds locally and at distances > 100m. That the mixture distribution best fit the data implies that different physical mechanisms govern local and long distance dispersal in *J. copaia*, namely that a proportion of seeds are uplifted above the forest canopy and are moved long distances by wind currents. We also test the hypothesis of directed dispersal to tree fall gaps by wind dispersed species by determining whether more seeds land in gap sites than expected compared to understory sites. This study is among the first direct measurement of seed dispersal distances using genetic markers in a tropical tree population.

Seed Dispersal by Taiwan Macaques at Fushan Experimental Forest

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Different animal species may have different impacts on seed dispersal, depending on their foraging and ranging behavior, methods of handling seeds, feeding and dispersal efficiency, time and stability of presence and abundance, etc. Our studies at Fushan LTER site confirmed that, although birds may play an important role in dispersing small seeds of certain plant species, the Taiwan macaques (*Macaca cyclopis*) are more important in affecting dispersal of large seeds of many dominant tree species due to their diverse diet, large body size, greater volume of fruit consumption, and abundance. They are able to carry large quantities of seeds away from the fruit plants in their cheek pouches and in their guts. Most of the seeds transported by the macaques achieve better germination rates than the seeds from intact fruits do. However, further studies are needed to examine whether post-dispersal predation and dispersal by secondary seed dispersers, such as rodents and dung beetles, are significant enough in affecting the locations, spatial distribution and densities of dispersed seeds, thus the survival and germination of seeds and the growth of seedlings.

Oral Presentations

Abstracts

(in the order they appear)

Tuesday, August 17, 2004

Tree Populations in Tropical Forest: Stability and Rare Species Rescue in Large-scale Plots from all Continents

Richard Condit & CTFS Workshop Group

Smithsonian Tropical Research Institute, USA

The Center for Tropical Forest Science forest-inventory plots provides estimates of the population density of close to 5000 tropical tree species. The large size of the plots allows us to assess the stability of tropical tree populations over time with reasonable statistical power. We present a quantitative measure of stability by presenting the variance in the annual rate of population change. We then examine whether there are taxonomic patterns to population change: do species within a family tend to show similar population changes across forests? Finally, we test for rare-species rescue by examining whether rare species increase in abundance relative to common species in all the plots.

Ten Years of Forest Dynamics in a Fragment in Bukit Timah, Singapore

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The island state of Singapore has suffered more than 99% loss of forest cover since European colonization in 1819. Bukit Timah Nature Reserve lies in the center of the Island and includes a 70 ha fragment of unlogged forest. We censused all trees ≥ 1 cm dbh in a 2-ha plot of the forest over a ten-year interval, 1993 to 2003. Density of trees (6476 ha^{-1}), mean basal (36.2 m^2 ha^{-1}), the species-rich families and dominant species display characteristic features of the lowland Malayan coastal hill forest.

In general, the decade of change showed a thinning of the understory and the upper canopy, with a slight increase in the mid size trees. Total trees declined 11.2%. Trees over 30 cm dbh also declined about 20% from 218 to 198 while basal area declined from 35.82 m2 ha-1 in 1993 to 32.79 m2 ha-1 in 2003.

Hyper-dynamism was evident in growth and mortality. Annualized mortality was 2.98 % while mean growth for 613 trees over 10 cm dbh at Bukit Timah was 2.59 mm per year. The net annualized recruitment rate was 2.4 %. Neither invasive species nor early successional species showed increasing abundance in the plot.

Bukit Timah had only 295 species ha^{-1} – low compared to Pasoh Forest. Although the 2003 census included 11.5 % fewer trees than the 1993 census, the numbers of species actually increased by two. Differences in diversity indexes between the 1993 and 2003 census were not statistically significant. Nevertheless, trees newly recruited into the plot in the ten year inter-census period had a Fisher's alpha slightly higher than for the forest as a whole, while the trees that died were of slightly lower diversity. Nevertheless, the distribution of species by abundance class suggests that Bukit Timah increasingly suffers a surplus of species with 1 or 2 individuals and an excess of species with 512-1024 individuals, a pattern that was exaggerated in the 2003 census.

The summary view is that continued species loss is expected, and is evident in the shifting abundances, however such loss is exceedingly slow for trees and is not specifically documented by ten years' evidence. Whether such loss is exaggerated or diminished by hyper-dynamism is unclear.

Typhoon Disturbance and Forest Dynamics in a Subtropical Rainforest: Does the Response of New World Forests Characterize the Response of Old World Forests?

Teng-Chiu Lin[1], Lih-Jih Wang[2], Kuo-Chuan Lin[3], Steven P. Hamburg[3], Yue-Joe Hsia[5],
Hen-Biau King[3], Fu-Wen Horng[3]

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Strong tropical storms are known to affect forest dynamics in both tropic and temperate regions. Yet, our understanding of cyclone (typhoon and hurricane) effects on forest dynamics disproportionately comes from studies of forests in the New World. New World hurricanes occur with frequencies an order of magnitude lower than typhoons in the Northwest Pacific and the land areas affected are only one third as large.

We summarize the long-term effects of typhoons on forest dynamics at the Fushan Experimental Forest (FEF) in northeastern Taiwan and compare them to patterns seen in New World forests. At FEF over the past 50 years typhoons with hurricane level intensities have impacted the forest 1.4 times/year, while Puerto Rican forests have experienced 0.07 hurricanes/year over the past 100 years and New England over the past 300 y has experienced 0.02 hurricanes/year. Typhoons result in limited stand damage at FEF, even in 1994 when there were six typhoons only 1.4% of canopy trees were blown down. The most common and important type of typhoon damage is defoliation. Frequent canopy defoliation maintains high understory light levels, allowing for the establishment of pioneer and late successional species, thereby maintaining species diversity in the absence of large canopy gaps, in contrast to that seen in the New World tropics or New England. Frequent typhoon disturbances at FEF appear to limit tree growth by limiting leaf area index. The increased vulnerability of taller trees to be blow down appears to have lead to the development of a short stature of the forest, 10.6 m, despite the old growth nature of the forest.

At FEF typhoons contributed 20% of the total precipitation flux of the ions found in sea salt aerosols but less than 10% of anthropogenically enriched ions such as SO_4^{2-} and NO_3^-, as typhoons do not pass over any industrialized land masses prior to arriving in Taiwan. In the New World the rarity of hurricanes results in their having a very limited influence on nutrient inputs to forests. Although typhoons contribute very little to P input, the stream export of total P is very high 9-23% of above ground standing biomass P and 50% of total outputs. The P limitations of the FEF forest suggest that the high levels of P lost during typhoons may impact overall net ecosystem productivity, unlike New World forests. Stream water concentrations of total P, $NO_3^-$and NH^{4+} increase dramatically during

typhoon disturbance and lasted for several days in contrast to the one to several years observed in Puerto Rico following hurricane Hugo. The rates of hurricane disturbance in Puerto Rico have been referred to as frequent and rates of stream water chemistry recovery as rapid, yet by contrast FEF experiences an order of magnitude more frequent events and streamwater returns to pre-event nutrient 100 times faster. Secondary succession occurring at large blown down gaps after hurricane disturbance contribute to the retention of nutrients in the soil profile and help the recovery of stream water chemistry to pre-hurricane levels at Puerto Rico. At FEF large gaps are rare and most trees survive from typhoon disturbance and are capable of taking up nutrients continuously. Slower foliage decomposition at FEF helps reduce the loss of nutrients in general allowing for greater plant uptake. Without high nutrient retention FEF could be potentially experience greater nutrient loss and diminished net ecosystem productivity. Our results indicate that tropical cyclone effects on forest dynamics differ significantly between the New Word and the FEF. Assumptions of the similarity of forest responses to cyclonic events in the new and old world are suspect and there needs to be a major research effort to characterize the effects of the majority of such events which occur in the Pacific region.

Biodiversity and Forest Dynamics in Central Africa

Duncan Thomas

Smithsonian Tropical Research Institute, USA

Central Africa contains the second largest block of closed-canopy tropical forest in the World and is home to more than 20,000 plant species. The sustainable management of these forests is becoming a major objective of both local Governments and international aid organizations. However, the distribution of the biodiversity and the dynamics of the forest trees remains so poorly known that most forest conservation and management in the region is implemented without much scientific basis for the interventions. Large forest dynamics plots are one of the fastest ways to increase the basic knowledge of the forest ecosystems; two CTFS programs are already in place in the region and more are planned for the near future. This presentation presents the management issues and the research needs for the main types of forest, and discusses how forest dynamics plot programs are addressing these issues and how this effort can be expanded in future.

Patterns of Mortality, Recruitment and Population Change (1988 - 2000) in a Tropical Dry Deciduous Forest at Mudumalai, Southern India

R. Sukumar, H. S. Suresh, H. S. Dattaraja and S. Srinidhi

Centre for Ecological Sciences - Indian Institute of Science, India

A 50-ha permanent plot set up during 1988-89 in tropical dry deciduous forest at Mudumalai, southern India, is being enumerated annually for mortality and recruitment, and once in four years for changes in stem sizes. The total population of individuals >1 cm dbh reduced from 25,554 (72 species) in 1988 to 15,351 (65 species) by 1996, but then increased to 18,161 (73 species) by 2000. The most abundant canopy tree, *Lagerstroemia microcarpa*, maintained its population size during this period but three other common canopy species, *Tectona grandis*, *Terminalia crenulata* and *Anogeissus latifolia*, declined moderately. The population of one common understorey species, *Cassia fistula*, fluctuated considerably but registered a net gain, while two other understorey species *Kydia calycina* and *Helicteres isora* declined steeply.

Mean annual mortality rates for all stems >1 cm dbh averaged 7.0%, but varied across size classes with the highest rates in the smallest sizes (27.6% for 1-2 cm) and very low rates in the largest stems (0.6% for stems >32 cm). Fire was the main agent of mortality in the smaller size stems (1-4 cm), herbivory by elephants in medium sizes (4-16 cm) and other causes for the larger stems (>16 cm). Inter-annual variability in mortality rates was higher in general for fire-related mortality as compared to either elephant herbivory or other causes.

Recruitment rates (stems growing to >1cm) averaged 4.1% per annum over the 12-year period, and were highest during non-fire years. Practically all the >9,000 recruits were vegetative sprouts from roots of previously-burnt stems with more than half these being of *Cassia fistula*. Among the four most common canopy trees *Terminalia crenulata* did not have a single recruit and *Anogeissus latifolia* had only a single recruit, while *Lagerstroemia microcarpa* and *Tectona grandis* recruited moderately. Species varied considerably in turnover rates with the understorey *Cassia fistula* having one of the highest turnovers among common species. Interestingly, the basal area of all individuals increased overall from 24.4 m^2/ha in 1988 to 25.9 m^2/ha in 2000 due to an increase in stems >32 cm dbh, a consequence of low adult mortality. The implications of fire and other factors in the dynamics of the Mudumalai dry forest are discussed.

Tree Diameter Growth Patterns in the Dry Deciduous Forest of Mudumalai, Southern India

Cheryl Nath, N.V. Joshi, H.S. Suresh, H.S. Dattaraja, R. Sukumar

Centre for Ecological Sciences - Indian Institute of Science, India

Tree diameter and girth data obtained from the 50-ha permanent vegetation monitoring plot of Mudumalai Wildlife Sanctuary, southern India, were examined for significant patterns in growth rates. The main objective was to identify sources of variation in linear and relative growth rates of trees during 3 four-year intervals from 1988 to 2000.

The average linear growth rate per interval ranged from 1.84 mm/yr to 3.32 mm/yr and the average relative growth rate ranged from 0.013 to 0.025, with significant variation across size classes. The middle interval, 1992-1996, showed significantly depressed growth across the plot. There was high linear diameter growth in small stems and a trend of increasing linear and basal area growth in large stems, while relative growth rates declined steeply across small size classes.

Growth rate distributions in many size classes were significantly positively skewed and individual growth rates were significantly correlated over time. Across three different growth forms (canopy, understory, shrub) shrubs had the lowest growth rates in almost all intervals and size classes where they were present, while understory trees had generally faster growth rates than canopy trees in the smallest size classes.

Results indicate that there is considerable variation in tree growth rates in the Mudumalai 50-ha plot community. While there is evidence for a community-wide pattern of depressed growth rates during one interval, there is also evidence for variation patterns associated with individuals and groups within the community.

Positive Effects of Diversity on Growth and Recruitment in Tropical Rainforests

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Are there benefits to organisms that live in diverse environments, and if so what generates these benefits? Here we present data from seven New and Old World Forest Dynamics plots, showing that with few exceptions there are highly significant positive correlations of local diversity with recruitment, rate of growth, total area at breast height, and average tree size. We also use these data to examine the relative contribution to these benefits of the three major classes of model that have been proposed to account for ecological diversity. The neutral model, which predicts that trees interact in the same way with trees of the same and other species, and that there should therefore be no benefit to diversity, can be largely excluded. Strong support is found, however, for (a) models that depend on spatial and temporal storage effects, in which different species can interact differently with combinations of physical and biotic features of their environment, and (b) Janzen and Connell models, in which the growth and survival of species are inversely related to their abundance, often because of the frequency-dependent effects of pathogens and seed-predators. Effects traceable to these two classes of models may account for the majority of the advantage of diversity. An advantage to a diverse environment is not by itself sufficient to maintain diversity, but the diversity can be maintained if the advantage is the result of frequency-dependent host-pathogen interactions and positive host-host interactions.

Evaporation at Two Mountain Forests in Taiwan

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Cloud forest covers an extensive area in Taiwan and is very important in terms of headwater watershed management. Deposition of fog plays an important role in the hydrological water balance and in the cycling of nutrients and pollutants. The Fushan (FS) and Yuan Yang Lake (YYL) long term ecological research sites offer a unique opportunity for micrometeorological experiment and for studying the water balance of mountain forest ecosystem across a transect along the North Eastern mountain range in Taiwan. Annual average precipitation at both sites exceeds 4,000 mm. Annual mean air temperature is 18°C and 13°C at FS and YYL, respectively. A relatively large amount of the rainfall at FS was caused by wind driven mist and storms, whereas high frequencies of fog and cloud coverage were observed at the YYL site. As a result, solar radiation energy at both sites is lower than in lowland plain areas in Taiwan. Studies at FS hardwood forest watersheds indicated that the annual water loss from a mountain mixed evergreen hardwood forest through evapotranspiration corresponds to a latent heat flux that equals the annual input of net radiation. Actual evapotranspiration estimated based on water budget from two gauged small forest watersheds were 600 to 700 mm. This estimation is close to evapotranspiration (670 to 695 mm) reported for tropical mountain cloud forest (Bruijnzeel and Proctor, 1993). From empirical equations based on storm based measurements, canopy interception loss, however, accounted for 500 mm (11 % of the annual rainfall). Potential evaporation calculated by Penman, Hamon, and Thornthwate methods were all around 800 to 900 mm per year. Since the annual net radiation at Fushan forest was only 920 to 940 mm equivalent water depth, net radiation alone could not be the sole energy source sustaining such a high amount of evaporation rate, especially during misty weather conditions. In August / September 2002, measurements of the CO_2 and H_2O exchange above the canopy at YYL site were taken. Some preliminary results suggested that the long wave radiation is balanced during conditions of dense fog. However, even without the radiant energy input to the canopy, H_2O flux measurements still show upward fluxes that indicated the intercepted fog water is evaporated. Considerable downward sensible heat flux can also be detected in the evening hours with relative dry and strong down slope wind. The result indicates that local-scale advection (downhill wind) heat flux is the main energy source that provides the energy for evaporation of wet canopy during night time. The rough terrain at FS precludes the application of fluxes measurement with eddy covariance technique. However, it is speculated that sensible heat flux comes with advection may also provide the additional heat source in additional to the low radiation energy input for the evapotranspiration in such a hilly region.

Poster Presentations

Abstracts

(in alphabetical order)

August 16-17, 2004

Large Tree Species Composition, Sun-exposed Crown Area and Growth on Barro Colorado Island, Panama

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The relationship between light and growth has been derived entirely from small trees and saplings, yet the highest rates of photosynthesis and greatest biomass in the forest come from upper canopy trees. Not only are we almost entirely ignorant of the impact of light on large tree growth, but there are no studies of the basic species composition of the upper canopy in a tropical forest. In this study, we use stereo photographs of the 50-ha forest dynamics plot on Barro Colorado Island, Panama to quantify the composition and structure of the upper canopy and to examine the relationship between direct light availability and large tree growth.

Viewing the forest from above gives a different perspective on the species composition and dynamics of the BCI plot. Overall species diversity is much lower in the upper canopy, but the upper canopy is dominated less by common species than the whole tree community. Gap-regenerating species dominate the upper canopy. There are many large trees with dbh > 20 cm dbh without sun-exposed crowns. For individual species, there was a range of relationships among basal area (BA), sun-exposed crown area (ECA) and growth (wood volume increment). Thirty-three percent of the species showed a strong relationship between ECA and growth. Only 15% of the species showed a stronger relationship between BA and growth than ECA and growth. Over 50% showed no relationship of growth with either ECA of BA. The variable relationship between crown area, basal area and growth can be used to define species in terms of their traits as canopy-dwelling trees, rather than just relying on traditional classifications (gap/shade regeneration) based on seedlings and sapling performance.

The Seed Rain in a Subtropical Rain Forest, Fushan, Northern Taiwan

Chia-Hao Chang-Yang & Chang-Fu Hsieh

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The purpose of this study is to understand the temporal and spatial variation of the seed rain in a subtropical rain forest of Fushan, northern Taiwan, and try to probe into the reproductive strategies and regeneration mechanisms of dominant tree species.

A total of 87 0.5-m2 seed traps were placed in a 25-ha plot established in Fushan Subtropical Rain Forest. All seeds, fruits, seed-bearing fruit fragments, and flowers > 1 mm in diameter falling into the traps have been collected every week from Sept. 2002 to Mar. 2004. All samples were identified to species and separated into mature fruits, mature seeds, capsules, fruit fragments, immature fruits, and flowers. The viabilities of all mature seeds were also investigated in the meantime.

All seeds were counted and sorted into 67 species, belonging to 37 families and 58 genera. There were 6877 seeds collected from 87 seed traps, and the biomass of falling fruits and flowers was 0.26 t/ha and 0.11t/ha during 2003. The highest biomass of the seed rain belongs to *Limlia uraiana* and the largest amount belongs to *Schefflera octophylla*. The onset and duration of seed rain varied considerably among each species in this forest and that can be categorized into three types: (1) Apr. to Jun., (2) Sept. to Dec., and (3) fruit falling all the year. There are only 3 species whose fruits fall all year round, 5 species during Apr. to Jun. and others during Sept. to Dec. Species with the largest potential fruit amount was *Limlia uraiana*, and the next was *Castanopsis carlesii*, but the successful fruiting rates of these two species were less than 0.1%. Species with the highest successful fruiting rate was *Lagerstroemia subcostata*, and the next was *Glochidion acuminatum*. A large proportion of fruits are immature fruits in species. Percentage of seed viability is quite different among main species, and ranges from 26% to 99%.

The reproductive strategies of the dominant forest tree species are quite different from each other. Species like *Schefflera octophylla* and *Glochidion acuminatum* produce lots of seeds but with worse quality to overcome the hazards in each stage of fruiting. On the other hand, *Machilus thunbergii*, *Machilus zuihoensis*, and *Litsea acuminate* produce better quality seeds for their regeneration. The successful fruiting rates of *Limlia uraiana* and *Castanopsis carlesii* are extremely low. More researches are needed to understand the role of seed rain in their regeneration.

Flowering and Fruiting Phenology at a Strongly Seasonal Tropical Forest at Korup, Cameroon

George Chuyong

University of Buea, Cameroon

Forest regeneration whether by natural or artificial means depends on the supply of viable seeds. Initiation of flowering and consequent fruit development in tropical species is controlled by complex interaction of genotype and different environmental cues which are poorly understood. Using fortnightly phenological records of flowering and fruiting of a large sample of mature trees and treelets in and around the Korup Forest Dynamic Plot, we evaluated the role of climatic factors as the possible trigger for elevated community flowering and fruiting. Daily weather records were taken at the Bulu station approximately 16km away from the plot.

The main flowering of most species was January to July and fruiting from June to October. Most species flowered and set fruits to varying degrees most years. In some cases immature fruits were dropped with effectively no seed fall as was the case with *Hymenostegia alfzelii* in 2001. In 2000 and 2002 there were relatively elevated levels of flowering and fruiting in most species and possibly 2004 which could be considered as periods of general flowering.

Though the dataset is not extensive enough for possible conclusions to be made, there are indications that the elevated flowering and fruiting in 2002 may have been triggered by the comparatively severe dry season as well as the low temperatures felt. Several other possibilities exist that will need further investigations.

Palanan Forest Dynamics Plot: Floristic Diversity and Stand Structure of a Lowland Evergreen Forest in NE Luzon, Philippines

Leonardo Co *et al.*

University of the Philippines & Conservation International, Philippines

Floristic diversity and stand structure of a lowland mixed dipterocarp forest in NE Luzon is presented, based on the results of a complete mapped enumeration on the 16-ha Palanan Forest Dynamics Plot censusing all free standing trees larger than 1 cm dbh. This covers a total of 65,915 stems, belonging to 332 tree taxa, 166 genera and 66 families.

The Palanan forest is of special regional and global interest for several reasons. First, it contains at least 133 (46.2%) tree species that is endemic to the Philippines. Second, its northerly position at 17ºN latitude is unique among the CTFS-AA network of SE Asian plots in being fundamentally Malayan (rather than continental Asiatic) in composition, making it the most northern representative of aseasonal lowland dipterocarp forest. Third, its being located in a region periodically battered by devastating typhoons provides a venue to study forest dynamics under such disturbance regime in the Malesian tropics.

Plant Species Diversity of a Dry Tropical Forest, Mudumalai, Southern India

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The species richness and diversity in tropical forests have been well documented. A study was conducted to understand the species diversity in Mudumalai wild life sanctuary. The aim was to describe and compare relationships among plots using vegetation data with the environmental data. A series of 19 permanent 1 ha plots were established from east (dry) to west (wet). The important components of the ecosystem such as vegetation, soil, and climatic factors were analyzed by multivariate methods. Statistically significant correlation was observed among structural and floristic diversity with precipitation, soil and fire frequency. The structural and floristic diversity increased along the precipitation gradient. However, the recurring fires in this region had direct influence on the species distribution and richness.

We have studying the long-term dynamics of above heterogeneous sites since its establishment (1994-95). We examine the basic aspects of population dynamics, including changes in species population, changes in size basal area, recruitment and patterns and causes of mortality across moisture gradient.

A New Forest Dynamics Plot in the Central Amazon: Topography and Richness Estimates

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Central Amazonia harbors one of the most diverse forests in the world. One can find more than 280 species of trees with DBH more than 10 cm in a single hectare of 'terra firme' forest near Manaus, Brazil. That incredible diversity is accompanied by high landscape-level heterogeneity. Single hectares, 400 m apart, have around 30% compositional similarity, factoring in density differences among sites. We recently began a new Forest Dynamics Plot near Manaus, using CTFS protocols, and we present the description of the area, topographic map and some richness estimates based on previous work. The mean annual temperature for Manaus, some 90 km south of the plot, is 26.7 ^{0}C, with monthly means fluctuating only by about 2 ^{0}C. Maximum temperatures range between 35 and 39 ^{0}C and minimum temperatures between 19 and 21 ^{0}C. Cool air masses, often occurring at the transition between the rainy and dry seasons, can drop temperatures to 17 ^{0}C. There is a distinct dry season between July and September and these months normally receive less than 100 mm of rain. The plot is dissected by two small streams that flow south/north, in the middle of the eastern and western halves of the plot, respectively. The elevational range is around 46m with the highest point near the southeastern corner and the lowest near the northeastern corner. Richness based on 3 previous 1-ha plots suggest that we shall find 280-285 species per ha for trees with more than 10 cm DBH. Estimates based on parametric and non-parametric methodologies predict more than one thousand species for tress with more than 10 cm DBH. We anticipate our plot being among the most species rich in the CTFS network, rivaling the Yasuni, Ecuador 25-ha plot (~1100 species), despite occurring near the low end of the spectrum of soil fertility across the Amazon Basin.

Characterization of Tree Species in the Riparian Zones of the Luquillo Forest Dynamics Plot (LFDP)

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As human population increases, understanding and conserving freshwater systems becomes critical. Riparian vegetation zones are dynamic areas adjacent to flowing water that connect aquatic and terrestrial environments throughout the landscape. Natural riparian zones often have high species diversity and productivity, when compared to non-riparian vegetation, but the distinction is not always clear. Riparian zones may have species with locally high abundance that are restricted to few sites in the landscape. The LFDP has distinct vegetation areas reflecting land use history. We analyzed the distribution of trees ($\geq$ 10 cm dbh) relative to two permanent streams, to see if species distribution also shows distinct riparian zone vegetation. The majority of tree species (54 out of 60) occupied a range of distances extending more than 100 m away from streams. No species had a mean distance of stems < 20 m, although 57 species were within 20 m of the streams. Stem density was higher near streams, but stem diameter was not related to distance from streams. Species richness decreased with distance from streams, but there was no pattern for diversity (H') and distance. Using fifty randomly chosen 20x20 m quadrats we also found no relationship between number of stems, species richness or diversity (H') and distance from streams. Fuzzy set ordination of quadrat species composition indicates that, irrespective of land use history, within 50 m of a stream species composition is related to distance. At more than 50 m from a stream there appears to be no relationship between distance and species composition. This study suggests that this plot, in mid-montane wet forest, has no tree species (stems $\geq$ 10 cm dbh) restricted to riparian zones, and no distinct riparian vegetation was recognizable. The forest adjacent to the streams reflects the general species composition within the forest landscape.

Soil-borne Resources and the Distribution of Tree-species in Tropical Forests: A Study from BCI, Panama

Robert John *et al.*

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Abstract Not Available

Combining Ecological Site Quality with Potential Growth in a Productivity Model

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The goal of forest management is to manage forest resources reasonability and sustainability. In order to achieve this goal, forestry researchers should estimate the current resources and predict the outcome and condition of forest in the future. To obtain and update these data, we should develop forest growth and yield model in landscape level.

The productivity of forestland was evaluated with site quality, generally. The main methods for evaluating site quality were developed by direct factors of forest, such as growing stock or the stand height of dominant and codominant trees. We could evaluate the site quality of some tree species with the data of field investigation. The site quality of other species could not be evaluated in the same model and the site quality of different species could not be compared with. Based on this restriction, a well-designed ecological site quality (ESQ) method should be developed. This evaluation method could be got out of spatial limitation. The site quality of exotic species could be estimated, also. This model could compare the site quality of different species on the same site.

This research focuses on matching ecological site quality with required environmental attributes and habitat factors. The habitat factors included temperature, humidity of soils, water table, and soil available nitrogen. The required environmental attributes of China-fir were included the growing degree-day, draught-proof response, water table and available nitrogen of soil. To combine the ecological site quality index and the potential growth data from field surveyed, we could develop a spatial productivity model of China-fir. Then we verify the model with the field data of Hui-Sun. In addition, GIS were used to build up a spatial productivity model of China-fir. This spatial productivity model could be used to evaluate the productivity of one species among different regions and different environmental conditions. It could be used to evaluate the productivity among different species in the same site condition. The model could be applied to choose the planting species in some sites. We could use the spatial productivity model to estimate the growth of stand and cohort in different ecological site quality.

Short-term Dynamics of Tree Seedlings in a Subtropical Rain Forest, Fushan, Northern Taiwan

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To study the regeneration of forest tree species at seedling stage in the Fushan Subtropical Rain Forest in Northern Taiwan, we set up 87 stations in a 25-ha permanent plot. Each station includes one 0.5mm seed trap and three 1mm seedling plots. The purpose of this study is to understand the temporal variation of tree species seedlings, the relationship between seed rain and seedling bank, the influences of understory vegetation on tree species seedlings established, and to probe into the regeneration strategies of the main tree species.

There were six seedling censuses from Sept. 2002 to Feb. 2004. 5127 seedlings were found, belonging to 19 families, 28 genera and 32 species. Because of the mass germination of some species in a short period, there is a very large variation of seedling density with time. Numerous newborn seedlings were found in each re-census, especially in May 2003, and composed mainly of *Myrsine sequinii, Pleocnemia rufinervis, Litsea acuminata, Glochidion acuminatum, Machilus thunbergii, Machilus zuihoensis* and *Engelhardtia roxburghiana*. The tree species were divided into three groups based on the time between when their seed fell and their seedling germinated: 1. germinating quickly after seed fell, such as *Pleocnemia rufinervis*; 2. germinating with a short break, about 1 to 2 months, such as *Litsea acuminate* and *Machilus thunbergii*; 3. germinating after a dormancy of about half a year, such as *Myrsine sequinii* and *Glochidion acuminatum*.

The regeneration strategies of tree species are different from each other. *Myrsine sequinii* seedlings have a higher survival rate; *Schefflera octophylla* and *Glochidion acuminatum* product a lot of seeds to ensure enough seedlings; *Machilus thunbergii* and *Litsea acuminate* seedlings can live under a shade canopy for a long time, waiting for the chance to grow upward.

Budgeting Fluxes of Coarse Particulate Organic Matter in the Mountain Streams of Wulin Area

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Coarse particulate organic matter (CPOM) from terrestrial ecosystems is an important energy source for headwater stream ecosystems. One of the missions of Shei-Pa National Park is to conserve the natural resources, especially the Formosan landlocked salmon in the mountain streams of Wulin area. In order to identify major flows of energy and matter in these streams, budgets for CPOM and their spatial changes were determined in Chichiawan Stream, Kaoshang Stream, and Yousheng Stream from January to March 2004. Four fluxes of CPOM were quantified: vertical input, lateral input, fluvial transport input and fluvial transport output. The results showed that vertical input and lateral input were greater in Kaoshang Stream and Yousheng Stream. Fluvial transport was greatest in Kaoshang Stream, but least in the middle Chichiawan Stream. The high CPOM flux in Kaoshang Stream (197 g m-2 d-1) can be attributable to the high canopy cover. However, in January, algae comprising a marked proportion were observed in the fluvial transport of the middle and the lower Chichawan Stream due to the fall-off of periphyton from cobbles. CPOM was retained most (124 g m-2 d-1) in the upper Chichawan Stream.

Nitrous Oxide Fluxes in Two Different Subtropical Rainforests

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Nitrogen cycling in Fushan Experimental Forest is examined here. Nitrous oxide fluxes were measured over a 5 week period at the 5K sites, and we also applied nitrogen to small plots in two forms: urea and ammonium nitrate ($CO(NH_2)_2$ and NH_4NO_3). Post fertilization data of N_2O gaseous N loss are presented from the first three weeks of measurements. Results from in vivo fertilization are also presented for variable soil moisture treatments of field moist, elevated soil moisture, and 2:1 soil slurry over a chronosequence of 1d, 4d, 7d, and 11d. Hypotheses of soil moisture limitations on production of N_2O-N are tested to elucidate the magnitude of control water content exerts on $N_2O_{(g)}$ flux with this soil type. Temperate forests with high nitrification rates, condensed growing season, low annual precipitation, and significant organic soil horizons typically exhibit very small N_2O-$N_{(g)}$ losses (<2 % annually). Here, we show results from a subtropical forest with similar characteristics generating ~10% of annual N exports as N_2O-$N_{(g)}$ losses. However, N_2O-$N_{(g)}$ losses account for ~50% of annual export in other subtropical forests without organic horizons and no noticeable growing season. As tropical forests are expected to have the highest potential for large fluxes of nitrous oxide, a comparison is drawn between the two sub-tropical forests of Fushan and Luquillo experimental forests.

Seedling Dynamics in Yasuní National Park, Ecuador: Preliminary Results

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Many of the ecological mechanisms hypothesized to maintain the diversity of tropical forests invoke particular patterns of growth or mortality for the seed and seedling life history stages. Broad categories of these mechanisms include niche diversification or habitat specialization, differential recruitment or mortality due to varying densities/frequencies of or distance to conspecifics, and random fluctuations in species' abundances due to limited seed dispersal or recruitment. Six hundred seedling plots were established in 2002 inside the Yasuní Forest Dynamics Plot using the same protocol as has been used in the Forest Dynamics Plots in Barro Colorado Island, Panama and Pasoh, Malaysia. Data from the ongoing seedling plot censuses in Yasuní will quantify spatial and temporal patterns in seedling distributions and dynamics. I will compare these patterns to those predicted by mechanisms hypothesized to be controlling the composition of the seedling assemblage and determine the importance of each of these mechanisms to maintaining diversity in Yasuní. The study design also permits comparisons of seedling dynamics across sites, which may or may not share species or differ in numerous ways. Yasuní is a highly diverse terra firme rainforest in the upper Amazon basin and varies greatly in species diversity, rainfall, seasonality and biogeographic history from the Panamian and Malaysian sites. In extensions of this work, I will use manipulative field experiments to allow isolation of an explanatory mechanism for correlative patterns in the observational data. Here, I present preliminary results from the 2002-2004 seedling censuses in Yasuní.

Spatial Niche Analysis of *Quercus liaotungensis* in a Temperate Forest with 2D-Wavelet Analysis

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Although a variety of approaches have been proposed for spatial pattern analysis of large forest plots, it remains difficult in ecology to detect multiple scales of variability in latice data and to relate these scales to the processes that generate the heterogeneities. This study introduces two-dimensional wavelet analysis as a general interrogative technique for the detection of spatial structure in lattice data. Not only is it able to detect constituent components of hierarchical structure, but it can also display the locational information of the components. Patches and gaps of different spatial scales in graphical presentation of wavelet coefficient can be directly linked to the local ecological processes that determine patterns at stand or landscape scales. Derived from 2D wavelet transform, the calculation of wavelet variance can reduce the four-dimensional data of wavelet coefficient to two-dimensional wavelet variance function, and quantify the contribution of the given scale to the overall pattern. We illustrate the use of 2D wavelet analysis by analyzing two simulated patterns and identifying the regeneration pattern of *Quercus liaotungensis* in warm temperate forest, Northern China. Our results indicate that the recruitment of *Q. liaotungensis* occurs in the overlapping area between the patch of adult and canopy gap at scale 45×45-70×70 m2 and 20×20-30×30 m2. The regeneration pattern of *Q. liaotungensis* can be mainly ascribed to a trade-off between two ecological processes: recruitment around parent trees and the physiological light requirements of seedling and sapling. The results provide a general portrayal of regeneration pattern for dispersal-limited and shade-intolerant *Quercus* species. Two-dimensional wavelet analysis is a flexible tool with numerous potential applications particularly in landscape ecology or large plot analysis where several scales of pattern may be present simultaneously.

Soil-related Performance Variation and Species' Distribution Patterns in a Bornean Rain Forest

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Spatial distributions of tropical trees often correlate with environmental variation, suggesting that ecological sorting caused by niche differentiation may be important for maintaining species diversity. In a 52-ha forest dynamics plot in Bornean mixed *dipterocarp* forest, four soil types varying in fertility and moisture have been identified. Previous research found that the distributions of 73% of tree species in the plot were significantly aggregated on one of these soil types, leading to strong associations between floristic and edaphic variation. Here, we test the hypothesis that variation in performance (growth and mortality) underlies these edaphically-biased distributions. Annual growth and per capita mortality rates over 5 years were estimated for trees 1 cm in diameter to test whether performance varied among soil types, according to life history, and among species-aggregation patterns (soil type on which a species was aggregated). Mean growth and mortality rates were lowest on the poorest soil. Growth rates on each soil type correlated with soil fertility for pioneers, while mortality rates correlated with differences in soil fertility for both pioneers and late-succcessionals. Species aggregated on the poorest soil had the lowest growth and mortality rates. They maintained above-average growth rates only on the home soil type, but their mortality rates were below average on all soils. Conversely, species aggregated on richer soils maintained average or above-average growth rates on all soils, but their mortality rates were average or below-average only on richer soils. On each soil type, trees in successive diameter classes became increasingly comprised of species aggregated on that soil type, providing evidence of ecological sorting. Species were most frequently lost from the soil types on which they were not aggregated. The slope of the relationship between growth and mortality varied among soil types and was steepest on the poorest soil, suggesting that variation in the severity of the life history trade-off between high growth in high light and low mortality in low light partly mediates ecological sorting. Thus, variation in performance among soil types, especially related to the poorest soil, underlies species' distribution patterns in this forest and likely influences the structure of tropical forest communities.

Community Structure and Spatial Pattern of Major Tree Species in an Old-Growth Mixed Temperate Forest at the Cinsbu Area, North Taiwan

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Species composition and the spatial pattern of major tree species were investigated in an old-growth mixed temperate forest at the Cinsbu Area in North Taiwan. All stems >1cm diameter at breast height (dbh) were mapped on a 2.38-ha plot and the spatial distribution of stems of dominant species was analyzed. The dominant species in our study site are *Chamaecyparis formosensis, Cyclobalanopsis sessilifolia, Eurya loquaiana, Ilex goshiensis, Adinandra lasiostyla, Sycopsis sinensis, Neolitsea acuminatissima* and *Tsuga chinensis var. formosana*. Besides four random distribution species, all other species showed aggregated distribution and formed clumped size. All random distributed species such as *Pasania kawakamii* were shade tolerant by skewness analysis, and they did not show any particular habitat preference. The species with large primary clump size (>1500m^2), reflected that their regeneration followed large-scale disturbances. All of the shade intolerant species such as *Eurya leptophylla*, had higher clumped index value and small primary clump size (46~93m2), revealed their generated strategy were associated with gap formation, and all of them were understory species. *C. formosensis* clumped at small quadrat size and were shade tolerant, reflect their regeneration were with following small-scale disturbances in this forest.

Permanent-plot Study of the Temperate Evergreen Broad-leaved Forest in Upstream Region of Nantzushien Creek in Central Taiwan

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The upstream region of Nantzushien Creek, an important habitat for wildlife, is located at the Western part of Yushan National Park in Central Taiwan. In this region, 10 ha (400m × 250m) permanent plot from the altitude of 1900m to 2030m above sea level will be set before 2005. In 2003, 1-ha plot (100 grids of 10m x 10m) was established, and species composition and spatial pattern of this temperate evergreen broad-leaved forest was studied. 3,196 individuals (DBH >1cm, height >1.3m) of 44 woody species in 37 genera and 23 families were recorded in this plot. The total basal area was 70.00 m^2/ha. According to important value (IV) index, *Fagaceae, Lauraceae* and *Theaceae* were the most important families (>77% for all). The ten most dominant species were *Castanopsis carlesii*, *Litsea acuminata*, *Cyclobalanopsis stenophylloides*, *Machilus japonica*, *Eurya leptophylla*, *Pasania kawakamii*, *Alnus formosana*, *Eurya loquaiana*, *Rhododendron ellipticum* and *Machilus zuihoensis*. Their total percentage of IV accounted for 79.6% of all species. The vegetation of this 1-ha

plot was recognized as the Upper *Quercus* forest zone according to the classification scheme of Su (1984).

Temporal and Spatial Changes in Abundance and Composition of Epilithic Periphyton in the Mountain Stream of Wulin Area, Central Taiwan

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One of the missions of Shei-Pa National Park is to conserve the natural resources, especially the Formosan landlocked salmon in the mountain streams of Wulin area. In order to understand the dynamics of the Formosan salmon, it is necessary to characterize the abundance and composition of the major primary producers, epilithic periphyton, in the streams. Therefore, the purposes of this study are: 1. to determine temporal and spatial changes in the abundance and composition of the epilithic periphyton in the streams of Wulin area, and 2. to assess which environmental factors correlate with the changes. Epilithic periphyton was sampled monthly in Chichawan Stream, Kaoshen Stream, and Yeausheng Stream for a period of 2 yrs from January 2002 to December 2003. Periphyton abundance peaked in summer. No significant differences were detected among the three streams. Diatoms were the most dominant species. Most of the diatoms belong to pennatae genera, of which Achnanthes was the most dominant throughout the year.

Classification and ordination analysis showed that the periphyton compositions were barely separated among the three streams, but they were distinct between the wet and dry seasons. This suggests that the epilithic periphyton in the streams of Wulin area was structured mainly by season, but not by site. Correlation analysis further indicated that temperature, SiO_2, and conductivity best explained the changes in the periphyton composition.