Book of Abstracts

LBA-ECO 9th Science Team Meeting
November 10-12, 2005
Conference Center of the American Chamber of Commerce
São Paulo, SP, Brazil

available online: http://www.lbaeco.org/lbaeco/meeting9/ab_intro.htm

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This abstract book contains the oral and poster abstracts scheduled to be presented at the LBA-ECO 9th Science Team Meeting.

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Parallel Oral Session 1

1A: Terrestrial Biogeochemistry

1.1: Soil Emissions of N2O, NO and CO2 Under Different Crops and Pasture in the Cerrado Region

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Agricultural activities in the Cerrado region have intensified in the last two decades. Pasture is the main land use but the expansion of crops like soybean and corn is characterized by more intensive soil management. Our objective was to determine the soil-atmosphere fluxes of N_2O, NO and CO_2 in plots of soybean, corn, irrigated common bean, cotton, pasture and native vegetation in the core of the cerrado region (Planaltina and Cristalina, Federal State of Goiás). Measurements were done monthly as a function of the cultivation practices (plantation, fertilizations, and harvest). Total emissions were calculated for the cultivation period of the different crops and for the rainy season for the pasture sites and then calculated for the total cultivated area in Central Brazil according the IBGE census data. The highest NO emissions (kg N-NO ha^{-1}) were estimated for the cotton cultivation (0.8), followed by irrigated bean and corn (0.3), soybean (0.2) and native cerrado (up to 0.3). In relation to the CO_2 fluxes, higher emissions (Mg C-CO_2 ha^{-1}) were also found under cotton (9.4), followed by corn (8.7), bean (6.9) and soybean (5.3). In the native areas, fluxes varied between 5.5 and 12.3 Mg Mg C-CO_2 ha^{-1} for the same period of cultivation. In spite of the low NO and CO_2 fluxes measured during the soybean cultivation, the increase of the new planted areas have enhanced the regional emissions to levels that surpassed the other crops. In 2002/03, the planted area of cotton in Central Brazil was 476,472 ha, what corresponded to emissions of 384.6 Mg N-NO and 0.004 Tg C-CO_2, while soybean (6.960.722 ha) contributed with about 1,388.6 Mg N-NO and 0.04 Tg C-CO_2.

1.2: Effects of Fertilizer Addition on Microbial Respiration and Uptake of Carbon Monoxide in a Cerrado Soil.

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The savanna area in central Brazil (Cerrado) is undergoing rapid agricultural land use changes and these changes are often accompanied by fertilization of the land. Because fertilization is a widespread management practice in the Cerrado, it is important to understand the effect that such treatments have on the microbial decomposition rates of soil organic matter (SOM) of various qualities. In this study, we conducted laboratory incubation studies on the effects of added fertilizers on bacterial production of carbon dioxide (CO2) and consumption of carbon monoxide (CO) in soil samples obtained from native Cerrado areas (20-50% canopy cover). The effects of added fertilizers were investigated by comparing fluxes in controls with no added fertilizer and soils with added nitrogen (40 µg/g of soil as (NH4)2SO4) and phosphorus (1 mg/g of soil as Ca(H2PO4)2+CaSO4•2H2O) in gas-tight jars maintaining the same soil moisture level through out treatments. Soil respiration was analyzed assuming that the soil organic matter (SOM) could be described by a two-compartment model (labile and refractory SOM). Results indicate that during the first 10 days, respiration from the labile component of the SOM was enhanced by addition of both fertilizers. However, in longer-term incubations (>32 days) addition of phosphorus produced the largest enhancement in respiration from the more recalcitrant SOM. CO was taken up by the soil cores in all cases and the uptake was quantified as deposition velocities. The deposition velocities were enhanced by the addition of fertilizer with particularly large effects observed with soil cores amended by phosphorus. Observed mean deposition velocities at 28oC were: control 0.0059 cm s-1; with added N 0.0081 cm s-1; and with added P 0.010 cm s-1.

1.3: Atmospheric aerosols in Central Amazonia and Atlantic Forest: chemical analysis, source identification and absolute apportionment.

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Fine and coarse aerosol particle have been measured in rainforest areas in Central Amazonia (Balbina site) and south east regions in Brazil (Intervales site). Both sites are in regions relatively free of anthropogenic influence, representing the natural atmospheric

condition and composition of atmospheric aerosols. Sampling of aerosols was performed using stacked filter units for fine (dp < 2 um) and coarse (2< dp< 10 um) mode particles, and submitted to elemental analysis by Particle Induced X-ray Emission (PIXE) and ionic fraction concentration measurements by ionic chromatography. The average fine mode concentration were different in wet (2.1ug/m3) and dry (6.2ug/m3) seasons in the Balbina, as a consequence of biomass burning, originated from highly impacted areas by anthropogenic activities in the Forest. On the other hand, coarse aerosol concentration did not present differences when comparing wet and dry season. The elemental composition was dominated by organic compounds accounting for about 70% of the aerosol mass. Major trace elements were K, S, Si, Fe, Al and Mg and other minor trace elements such as P, Zn, Cl and other biogenic elements. For the Intervales site, backward air mass trajectory analyses indicate marine contribution, which explain high Cl concentration in this site. In Balbina, high concentration of soil dust tracers was observed during the wet season, a consequence of the long-range air mass transport from the Sahara desert. Source identification by factor analysis detected the presence of four major aerosol sources in both sites: natural biogenic aerosol, soil dust, sea salt and biomass burning.

1.4: Evidence of increasing leakiness of the nitrogen cycle along a secondary forest chronosequence in Eastern Amazonia

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Shifting cultivation has been used by small landholders in Amazonia for many generations, including over 100 years in the Zona Bragantina in eastern Pará. As these agricultural fields are abandoned for fallow periods, secondary forests in different stages of secondary succession develop. In order to understand the effects of land cover changes on the nitrogen cycle, we investigated the $\delta^{15}N$, C and N concentrations in soil and vegetation, and N_2O and NO emissions from soil in an old growth forest and along a chronosequence of secondary forests (6, 20 and 40 year-old) located in the municipality of São Francisco do Pará, Pará, Brazil (01,10 S; 47,45 W). For all sites, $\delta^{15}N$ increased and N concentrations decreased with soil depth in the first 50 cm of soil. Foliar $\delta^{15}N$ and N concentrations increased significantly along the secondary forest chronosequence, and foliar C:N ratio decreased. The emissions of NO + N_2O from the soil also increased with secondary forest age. These results indicate increasing N availability and increasing gaseous N loss with stand age. Foliar $\delta^{15}N$ correlated positively with estimates of annual soil emissions of NO + N_2O. The fact that the pattern of both soil and vegetation $\delta^{15}N$ is enriched in old forests compared to young forests indicates that annual losses of nitrogen relative to pools are greater in the older secondary forests. That is, nitrogen cycling is more closed due to N limitation during the first stages of secondary succession and becomes more open as the secondary forest ages and as rates of N cycling accelerate.

1.5: Evolution of the nutrient cycling process in agro-forestry systems growing on degraded pastureland in central Amazonia

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Litter production, deposition and nutrient storage were assessed at different times in a cluster of agro-forestry systems (AFs) growing up to 11-12 years of age on degraded pastureland in central Amazonia. In 5-6 years old AFs, litter production and accumulation where much lower but the nutrient stocks in the litter layer were similar to those found in the spontaneous second growth vegetation. One of the AFs (multi-strata, the most diverse in tree species, mainly composed by native fruit species), produced only ¼ of fine litter compared to the second growth, but showed stocks of P, K, Ca and Mg only 10-20 % smaller than the second growth, 4-5 years older and presenting higher biomass. At 11 years of age, the multi-strata AFs stored 3.6 Mg ha-1 of fine litter on soil surface (against 5.9 Mg ha-1 in the second growth), but the stocks of nutrients in the litter layer were all higher than in second growth (in kg ha-1): 4.38 of P, 4.78 of K, 47.8 of Ca, and 6.43 of Mg, against 1.60 of P, 3.78 of K, 25.1 of Ca, and 4.45 of Mg. Besides the higher quality of the litter produced by the AF species (e.g., high K and Ca contents in timber species; high Mg in peach palm litter), the addition of green manures (mainly from the legume species Gliricida sepium, used as living fence and periodically pruned) was instrumental to have a litter layer with better nutritional quality, and, thus, an adequate nutrient availability in the AF soils.

1.6: Nitrogen cycling in Brazilian tropical forests and savannas: an isotopic approach

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Due to its continental scale, Brazilian ecosystems span variation in climatic regime, topography, and geography and consequently in vegetation structure. Here we present data on foliar and soil delta15N and N concentration from areas covered with tropical (Brazilian Amazonian terra-firme forest and Atlantic forest), savannas encroached in the Amazon region and the Cerrado. There was an inverse relationship ($r = -0.72$, $p < 0.05$, $n = 130$) between soil C/N ratios and soil delta15N values (0-5 cm depth), with the forested ecosystems being more enriched in 15N with lower C/N ratios than the other areas. Positive correlation ($r = 0.40$, $p < 0.05$, $n = 3420$) was found between foliar N concentration and foliar delta15N, with the Amazonian terra-firme forests having the highest foliar delta15N as well as N concentration, followed by the Atlantic forest. Plant species from the savannas in the Brazilian Amazon as well as from the Cerrado, showed depleted foliar delta15N signatures; however, the range of foliar delta15N was wider in the latter. Most of the foliar delta15N values in the savannas from the Amazon and mainly in the Cerrado were negatives. The difference between foliar delta15N and soil delta15N was higher in ecosystems with more open canopies and that are nutrient-poor, such as the savanna ecosystems, appearing to be more efficient in conserving and recycling mineral N. Contrastingly, the forested Brazilian ecosystems are generally N-rich (open N-cycle) showing a lower difference on delta15N between soil and leaves.

1.7: Nitrogen limitation induced by slash-and-burn agriculture in the Brazilian Amazon.

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Given the important contribution of slash-and-burn agriculture to the release of mercury naturally contained in Amazonian soils into aquatic ecosystems, a study was conducted in an active colonization front area to better understand the varied impacts of small farmers practices on soil chemical properties. Soil sampling reflected the actual complexity of land-uses in relation to time, going from recently deforested sites to old plots submitted to various cropping and fallow cycles for over 20 years. Available nitrogen ($N\text{-}NH_4$ and $N\text{-}NO_3$) represented the most important nutrient loss in soils submitted to land-use. This decrease was fast for surface soils upon deforestation, staying low under all land-uses. Loss of $N\text{-}NH_4$ tended to be more important than for $N\text{-}NO_3$. Lower natural values of available nitrogen for clay-sandy soils compared to that of clay soils indicate that a lower clay content in cultivated soils might affect mineral nitrogen restoration, arguing for a more limited capacity of support for these soils. Under the current agricultural practices based on slash-and-burn, nitrogen seems to be a more limiting nutrient than cations are, at least during the first years of the varied land-uses. Only fallowing for periods beyond 20 years seems to revert available mineral nitrogen levels towards levels similar or superior to forested sites, probably through mechanisms related to the reestablishment of organic matter recycling. But current fallow length in the studied area is in the order of 3.5 years, thus aggravating nitrogen limitation in these old weathered Amazonian soils.

1B: Observing Land Cover

2.1: Forest structure and the relationship between light environment above and below the canopy in the Tapajós National Forest

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Canopy structure influences the balance, spatial and temporal distribution, and spectral quality of radiation of a forest. To understand the details of these interactions in primary moist forest at km67 in the Tapajós National Forest, Brazil (2° 51′ S, 54° 58′ W), we combined continuous high-frequency pyranometer and quantum sensor measurements above and below the canopy with observations of canopy structure made with a portable LIDAR system deployed from the forest floor. We describe the whole canopy budget of Photosynthetic Photon Flux Density (PPFD), the canopy reflectance and understory transmittance of PPFD, and the balance of direct and diffuse fractions. We examine the dependence of transmittance, sunfleck probability and duration on solar elevation angle, season, and sky conditions. From co-located measurements of PPFD and LIDAR structure along a 1000m transect we show the relationship between transmittance and overhead cover, surface area density, and local canopy height. From the distribution of local maximum heights (the hypsograph) we estimate the mean vertical pattern of within-canopy transmittance and absorbance.

2.2: Deforestation Dynamics in Mato Grosso Derived from MODIS Data

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Deforestation in the state of Mato Grosso constitutes approximately half of all deforestation in the Amazon Basin. The size and number of clearings has increased rapidly in the first half of this decade, largely driven by the grain-based, highly mechanized agricultural sector. Data from the Moderate Resolution Infrared Spectroradiometer (MODIS) at 250 m spatial resolution and daily temporal resolution permit characterization of deforestation dynamics and development of policies for land use management that were previously unavailable. First, MODIS data have enabled implementation of near real-time, biweekly identification of new deforestation clearings greater than 25 ha through the DETER project. Second, phenological information from time series of MODIS data facilitates discrimination of the type of land use, e.g. pasture or mechanized agriculture, following initial clearing. Third, the frequent acquisitions indicate that the timing of clearings has extended into the wet season, particularly in the case of new deforestation for mechanized agriculture. These examples illustrate the utility of medium resolution data that are acquired daily and available at no cost for operational applications throughout the pan-Amazon.

2.3: Annual pasture and cropland expansion in Mato Grosso from MODIS phenology metrics

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Rapid land cover conversion in the cerrado and transition forest zones for grain production and cattle ranching continues to fragment large tracts of these biomes in Mato Grosso. The pattern, spatial extent, and nature of these land cover transitions have important ramifications for ecosystem function but remain poorly characterized in this region. We use time series of cloud-cleaned MODIS NDVI and EVI at 250 m resolution to characterize land cover based on metrics of wet-season, dry-season, and annual phenology from 2000-2004. Distinct phenological patterns for forest, pasture and natural grasslands, cerrado, and cropland enable accurate classification of land cover types when compared to field validation data (overall accuracy = 85%). Annual assessment of land cover transitions captures the temporal dynamics of primary (e.g., forest to cropland) and secondary (e.g., pasture to cropland) transitions in the region. We estimate that more than 1.6 million hectares were converted to cropland between 2000 and 2004. The majority of new cropland resulted from the direct conversion of cerrado (35%) or forest (29%); conversion of natural grassland areas or planted pasture accounted for 36% of new cropland areas. While secondary transitions from existing cattle pasture to cropland are an important source of new agricultural production, our findings contradict recent statements that cropland agriculture is not directly associated with new deforestation activities. Separation of more seasonal cerrado vegetation from transitional tropical forest based on vegetation phenology also highlights land cover dynamics in a biome with no previous deforestation monitoring. Phenological information from MODIS is extremely important to monitor land cover dynamics, separate forest types, and estimate impacts of tropical forest replacement by grassland (C4) or cropland (C3) on regional hydrology, energy balance, and ecosystem function.

2.4: Examination of Canopy Disturbance in Logged Forests in the Brazilian Amazon using IKONOS Imagery

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Forest canopy gaps resulting from natural tree mortality and logging increase light in the understory, release nutrients, and create structural habitat for some species of flora, fauna, and fungi. The measurement of gap formation using remotely sensed data over broad areas would allow foresters and ecologists to study forest dynamics over greater areas than those available from plot level surveys. Previously, we developed a crown detection algorithm that used high resolution (1 meter) satellite image data. We have extended the algorithm to examine logged forests and the disturbances of such forests. Log decks and canopy gaps have spectral signatures that can be differentiated from surrounding trees in multi-spectral 4 m resolution IKONOS images. By combination of multi-spectral data with the higher resolution panchromatic data from IKONOS, our refined algorithm estimated gap size and frequency and spatial patterning. Remote sensing estimates of gap frequency and size will be useful for understanding carbon budgets and fire susceptibility in logged forests.

2.5: Normalized Difference Fraction Index (NDFI): a new spectral index for enhanced detection of forest canopy damage caused by selective logging and forest fires

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We developed a new spectral index, the Normalized Difference Fraction Index (NDFI) that enhances the detection of forest canopy damage caused by selective logging activities and associated forest fires. The NDFI synthesizes characteristic degraded forest cover fractions (Green Vegetation (GV), Non-photosynthetic Vegetation (NPV), Soil and Shade), derived from spectral mixture models, into a single metric that outperforms all individual fraction-based metrics NDFI is obtained by dividing the result of shade-normalized GV minus NPV plus Soil by the total sum of these fractions. The NDFI values range from -1 to 1, and are expected to be high in intact forest, due to the combination of high GV and canopy Shade and low NPV and Soil. In degraded forests, the NPV and Soil fractions are expected to increase, lowering the NDFI values relative to that of intact forests. Interpretation of the NDFI data is facilitated by a contextual classification algorithm (CCA) that utilizes detected log landings, which are the spatial signature of selective logging, as start locations for searching through NDFI im ages for canopy damage. This process allows us to separate canopy changes due to logging and associated forest fires from those caused by other types of forest disturbance. We tested these methods on more than 200 Landsat TM/ETM+ images. Information from forest transects, conducted along a gradient of degraded forests were used to evaluate the performance of the NDFI. Map accuracy of forest canopy damage using the CCA classifier applied to NDFI images, assessed with aerial videography images acquired in the Sinop-MT region, was 94%. The proposed NDFI - CCA classifier approach can be fully automated and, therefore, holds great promise as a forest monitoring tool in tropical forests.

2.6: The Carnegie Landsat Analysis System: An automated approach to large-scale canopy damage analysis

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The Brazilian Amazon covers more than 7 million square kilometers of South America, an area whose ecosystem structure and land-use variation cannot be studied at a regional scale without the use of remote sensing and automated processing that it makes possible. The Carnegie Landsat Analysis System (CLAS) has successfully demonstrated that automated Monte Carlo unmixing (AutoMCU) can be used to decompose the Landsat spectra into fractional cover indices of photosynthetically active vegetation (PV), non-photosynthetically active vegetation (NPV), and Bare Substrate (Bare) on a per-pixel basis over the entire Brazilian Amazon. These three indices make it possible to infer other biophysical parameters to further our understanding of ecosystem structure and type of disturbance. In this work, the new capabilities of CLAS to identify areas of probable logging events (PLE) using fractional cover indices and the automated methods to detect them will be described. The main components of the logging detection sub-system include an image differencing and atmospheric adjustment step, a pattern recognition step, and final integration step. By combining image differencing of fractional cover indices at annual intervals with pattern recognition techniques, CLAS can rapidly and routinely map PLEs over large areas. New ideas to improve and enhance the amount of automatic detection will also be discussed. CLAS has produced images of PLEs of the Brazilian states of Pará, Mato Grosso, Rondônia, Acre, and Roraima for three annual intervals (i.e., 1999-2000, 2000-2001, and 2001-2002). Examples of the results will be used to describe the capabilities of CLAS.

2.7: Selective Logging in the Brazilian Amazon

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Amazon deforestation has been measured by remote sensing for three decades. In comparison, selective logging has been mostly invisible to satellites. We developed a large-scale, high-resolution, automated remote sensing analysis of selective logging in the top five timber producing states of the Brazilian Amazon. Logged areas ranged from 12,075-19,823 km^2 yr^{-1} (+14%) between 1999 and 2002, equivalent to 60-123% of previously reported deforestation area. Up to 1,200 km^2 yr^{-1} of logging was observed on conservation lands. Each year 27-50 million m^3 of wood were extracted and a gross flux up to ~0.1 Gt C was destined for release to the atmosphere by logging.

1C: Terrestrial Carbon Fluxes (1)

3.1: Simulating the two-way interactions between vegetation biophysical processes and mesoscale circulations during 2001 Santarem field campaign

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The Simple Biosphere Model Version 2 (SiB2) is coupled with the CSU Regional Atmospheric Modeling System (RAMS) to study the two-way interactions between the land surface and atmosphere. SiB2 treats the vegetation explicitly and realistically (Baker et al. 2004), thereby incorporating the biophysical controls on the exchange of momentum, energy, water, and carbon between the two systems. The coupled SiBRAMS is used to reproduce dry season 2001 Santarem mesoscale field campaign. The simulation results are evaluated against flux tower and nearby meteorological station observations.

Previous study using RAMS with prescribed landcover-type specific CO2 fluxes (CO2RAMS) identified a low level convergence (LLC) zone near the east bank of Tapajos River (Lu et al. 2005). This feature is further investigated by the coupled SiBRAMS, where the feedback between the LLC and NEE is realistically captured. A comparison between SiBRAMS and CO2RAMS simulations for the same case is carried out. This highlights the impact of SiB2-calculated verses the prescribed CO2 fluxes, on simulated land-surface fluxes and near-surface meteorological conditions. We find short-term variations in CO2 flux are more accurately simulated with the more realistic canopy parameterization provided by SiB2.

In addition, the mechanisms for the formation of LLC line are further explored. When the background winds turn southeasterlies, the channelling effect from the Amazon River to the Tapajos River is compromised; however, the blocking effects of elevated topography start to take over, resulting in wind decrease downstream, and in turn the convergence line. Contrary to the channelling effect, in this case, the LLC line does not form exactly along the east bank of Tapajos River; it moves in the Eastwest direction, depending on the relative strength of the background winds and the physical blocking of elevated topography. This explains why the LLC line moves eastward after sunset when winds start to die down.

The persistent clouds near the east side of the Tapajos River have significant impact on observed ecosystem carbon flux and should be taken into account if tower fluxes are to be generalized to a larger region.

3.2: Ecophysiological characteristics of eastern Amazonian vegetation

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Plants exert strong influence on the exchange of carbon and water between terrestrial ecosystems and the atmosphere. When associated with environmental drivers, eco-physiological characteristics of the vegetation can be used by models to simulate rates of carbon and water exchange. While a mechanistic understanding of the processes of photosynthesis and transpiration is already available to the scientific community, a broader understanding of ecological processes is still needed. We evaluated eco-physiological characteristics related to gas-exchange of 29 plant species from both primary forest and pasture sites from eastern Amazônia. As a result, two major findings were evident. First, there was no evidence that dry season (or wet) had a consistent influence over leaf-level gas exchange. Although some species showed decreased carbon assimilation rates during the dry season, consistent with responses to water stress, the majority of the species (60%) showed no seasonal changes in assimilation rates or even increased assimilation rates during the dry season. Second, we observed large variability in eco-physiological characteristics among the species studied, indicating that plant composition might have a significant role in explaining inter-site variability in carbon and water cycle. Based on eco-physiological properties of the species evaluated, we were able to characterize six distinct functional groups. The adoption of the functional group approach can simplify the large variability observed among species.

3.3: Amazonian forest canopy-atmosphere gas exchange rates and in-canopy biogeochemical processes determined from radon-222

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Calibration work is complete on radon data sets consisting of multiple canopy height radon measurements every 15 minutes at

three LBA-ECO tower sites in the Tapajos National Forest (km67; km83) and a pasture site (km77) for up to 4.5 years with approximately 80% data coverage. The data sets reveal systematic temporal variations in total radon inventories in canopy air occurring on annual and diurnal time scales that are controlled by variations in turbulent mixing processes and soil radon fluxes. Results between the km67 and km83 sites are strikingly similar prior to selective logging activities. The magnitude of temporal variations in soil radon fluxes is controlled by changes in soil moisture content. The mean values of over 1200 soil radon flux measurements at km67, km83 and km77, range from 1.38 to 2.1 atoms/cm2/sec with variations controlled by inherent soil properties. The radon canopy inventory and soil flux data yield gas exchange coefficients that can be used to determine net fluxes of other gases plus canopy source and sink strengths. Calculated canopy air residence times range from minutes during turbulent daytime periods to over ten hours during calm nights.A flux divergence model has been developed that utilizes radon and other data to determine CO2 NEE independently of eddy correlation techniques. The model can also be used to calculate canopy trace gas production and consumption and canopy respiration rates versus height. Radon data is especially useful for independently quantifying gas physical transport processes on short term (hours or greater) scales during nighttime hours when canopy air residence times are longer.

3.4: From source to sink: tracing the effects of natural disturbance on tropical forest carbon balance

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Natural disturbance events play a critical role in carbon cycling in tropical forests, hence it is important to understand the detailed dynamics associated with response to disturbance. Carbon balance was estimated over 3.5 years in an old-growth site (km 67) in the Tapajós National Forest near Santarém, Brazil using eddy covariance and biometric methods. The first two years of eddy covariance results showed the forest losing modest amounts of carbon, and the biometric evidence (excess decomposition losses coinciding with high tree growth rates) led us to hypothesize that observed losses were the transient consequence of prior disturbance event(s) (Saleska et al, 2003; Rice et al., 2004).
Here we report an additional 1.5 years of flux data and results from biometric resurvey, which allow us to test predictions of the disturbance-recovery hypothesis, including: that the forest should eventually shift from source to sink, and that this should be due more to a fall-off in respiration than an increase in photosynthesis (e.g. Moorcroft et al., 2001). New measurements through the end of 2004 provide a preliminary confirmation of these predictions: the forest shifted from a weak source to a weak sink, due to a gradual decline (1.8 Mg C ha-1 yr-1) in ecosystem respiration. This is the first eddy covariance-based observation of the C dynamics during recovery from disturbance in a primary Amazonian forest, and it provides a unique dataset for improving links between vegetation demography and carbon dynamics in ecosystem models.

3.5: Seasonal variability of climate and micrometeorological CO2 fluxes across amazonian and Cerrado tower sites

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Climate data and CO2 atmospheric fluxes from six micrometeorological flux towers across the Amazonian and Cerrado biomes are compared on the seasonal variability. 15 day mean gross primary productivity at the sites is estimated using the daytime 30 min atmospheric CO2 fluxes. There appear to be a remarkable pattern of min/max GPP year round each site, concurrent with the length and intensity of the dry season each site.

3.6: Tree Mortality, Regional Disturbance, and Ecosystem Carbon Balance in the Central Amazon

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Recent studies indicate that changing dynamics in forests, affecting 75-85% of the Amazon basin that remain relatively undisturbed, may have impacts on regional and global processes as large as those due to land-use change. In particular, spatial and temporal variability in tree mortality rates may have marked impacts on ecosystem carbon storage. Nonetheless, variability in

mortality rates have not been thoroughly investigated from a regional perspective. This talk highlights efforts to carry out a formal synthesis of tree mortality variability from individual trees to landscapes by synthesizing field and remote sensing data. First, analyses of tree mortality data from forest inventory plots at key sites from across the basin has provided robust probability functions for annual tree mortality events, varying in size from 1-20 trees per event, with a spatial extent of 0.04 ha or less. For the largest natural Amazon forest disturbance events, analyses of Landsat TM data documented 5 to 3,000 ha blowdowns. A new approach has been developed employing space-borne imaging spectroscopy to quantify spatial variability in intermediate-scale mortality events of 0.1 to > 5 ha in size. By integrating these methods, tree mortality probability distribution functions, spanning the entire range from individual tree deaths to catastrophic 1000 ha blowdowns, are being developed. These functions are useful for parameterizing ecosystem carbon cycling models to better simulate how disturbance drives regional variability ecosystem carbon balance.

3.7: Amazon Drought Stress: Reconciling Models and Data

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The Amazon region of South America plays a significant role in global cycles of water, energy and carbon, yet it is also one of the most challenging biogeographical areas of the world to model correctly. Numerous global climate models have problems with anomalous dieback of the Amazon rain forest, which has been variously attributed to inadequate representation of rainfall, faulty soil moisture dynamics and an inability to correctly simulate drought tolerance of the vegetation. Such misrepresentation of the Amazon in global climate models is thought to lead to larger than observed excursions of the global carbon cycle. The Simple Biosphere Model (SiB v3.0) is a land surface model that describes the transfers of heat, water and carbon in the soil-vegetation-atmosphere continuum. SiB3 can be run at the ecosystem scale, as well as coupled to regional atmospheric and global climate models. In the past, SiB3 has exhibited the 'dry tropics' problem when coupled to atmospheric models. We have implemented new soil moisture and soil water availability parameterizations in SiB3 which link total plant available water throughout the rooting profile to stress on transpiration and photosynthesis. While these new parameterizations alleviated the stress on transpiration and produced improved diurnal fluxes of latent and sensible heat, the expected improvement with respect to land surface fluxes of carbon was less than expected. This paper explores the interactions between soil moisture, drought stress and net ecosystem exchange for Amazonia with SiB3 and the coupled solutions that are necessary to achieve more reasonable estimates of carbon fluxes.

1D: Carbon in Wetlands and Rivers

4.1: Boat-Based Eddy Covariance Measurements of CO2 Exchange Over Amazon and Tapajos Rivers and Lakes

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Recent reports based on floating chamber measurements suggest that gas evasion of carbon dioxide from the Amazon river and its tributaries to the atmosphere may play an important role in the regional carbon budget. Chamber techniques have inherent uncertainties due to their effect on the near-surface air turbulence. The micrometeorological technique of eddy covariance is attractive since it is a direct measurement of gas exchange and samples over a much larger area. In August 2004, we mounted equipment on a small riverboat and measured CO2 and H2O fluxes from rivers and lakes near Santarem, Para, over a 10-day period. Our sampling strategy included both "under-way" measurements and stationary (moored) 24-hour measurements. CO2 concentration in the Amazon river and a connected lake was 3000-5000 ppm, much higher than the Tapajos river and a connected lake (range 400-1200 ppm). Preliminary calculations indicate the turbulent "diffusion" coefficient agrees with existing ocean-based parameterizations for air-water gas exchange.

4.2: CO2 flux from rivers to atmosphere in Western Amazonia (dry season)

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As one of the possible means of carbon evasion from amazonian ecosystems, carbon fluxes in rivers must be surveyed in detail in space and time (Richey et al., 2002). Here we present partial data on the CO2 flux from water to the atmosphere in some of the main rivers in western Amazonia. Measurements were made by attaching an infrared gas analyzer (LI-820, LiCor) to a chamber, which floats on top of the surface water. Increase in CO2 concentration inside the chamber over time was used to calculate the fluxes (similar to soil CO2 fluxes). Data presented refer to a survey done in the dry period of 2005, for the following rivers: Jurua, Moa, Envira, Tarauaca, Acre, Purus and Madeira. Average flux was 6.2 ± 4.5 μmol m-2 s-1. This high variability (CV = 74%) was probably due to differences in pCO2 (not presented here); great spatial variability in soil types in each sub basin, water chemistry (pH varied from 6.4 to 8.6; conductivity from 100 to 385 μS). The smallest flux was recorded at Upper Purus (1.01 μmol m-2 s-1),

which also presented the more basic pH (8.6) although Upper Purus presents much higher fluxes (9 µmol m-2 s-1) during the high waters when its pH drops to less than 7. The highest flux was presented by also Purus river at its mouth near Solimões (15.3 µmol m-2 s-1 pH 6.4). Next step to be taken in our study is to estimate total surface area of these rivers in order to extrapolate these fluxes into a regional context.

4.3: From Small Streams to the Sea: An LBA-III Multi-scale Synthesis of Carbon and Hydrological Dynamics across the Amazon Landscape

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Recent work by a number of research groups on the overall patterns and dynamics of pCO2 in Amazonian waters has confirmed and expended upon the perspectives of the importance of outgassing from aquatic environments in the Amazon carbon budget. While provocative, these results represent a work in progress; much remains to be done. It is important to be able to track processes from a local source to downstream aggregation. That is, the sequence of processes, from small to large scales, which define the role of fluvial systems in the C cycle of the Amazon must be identified, and systematically linked together. Models are needed to be able to express river chemistry in explicit, process-based terms of the attributes of the landscape, and the movement of water through the landscape. This challenge represents an overall "synthesis" arena, for LBA. This talk will outline the approach to be taken by the CD-33 project, as an invitation to all interested parties to participate. Briefly, using workshops and on-going activities, a "Virtual Scaleable Basin" modeling and cyber-informatics infrastructure will be developed. It will incorporate a fine-scale solute export model, a scaling hydrology model, and a net ecosystem production module (NPP), all driven by surface forcing. The overall objective is to evaluate coupled the carbon and hydrologic dynamics of the Amazon Basin, under current and changing conditions.

4.4: Seasonal changes in phytoplankton distribution in floodplain lakes in response to Amazon flood pulse derived from MODIS images

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Several studies of primary production of Amazonian floodplains suggest that phytoplankton represent a small fraction of the total. Isotopic studies, however, have shown that fish derive significant amounts of carbon from algae. To examine the wide range of spatial and temporal variability in algal abundance, we present results from field and satellite analyses. The synoptic, medium resolution (250 m) and relatively high frequency cloud free overpasses provided by Terra MODIS reflectance images permits identification of water color changes related to chlorophyll concentrations. Our study area is located in a floodplain reach from Parintins (Amazonas) to near Almerim (Pará). A three end-members mixing model designed to uncouple three fractions (high suspended inorganic matter, low inorganic suspended matter, and high chlorophyll a concentrations) was tested in Lake Curuai (S1.5o, W55.43o) based on field sampling done almost currently with satellite overpasses. During high water, phytoplankton patches were confined to lakes closer to terra firme under the influence of clear water inflow, whereas during the rising and falling water stages, the patches were more evenly distributed over the floodplain

4.5: Multi-scale analyses of inundation and wetland vegetation dynamics: Applications to carbon dynamics

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Our optical and microwave remote sensing analyses continue to refine the spatial and thematic accuracy of inundation and vegetation in the lowland Amazon basin. Three characteristics observable using satellite remote sensing are being used in our classification system: vegetative structure, inundation periodicity and water color. High-resolution basin-wide and regional mosaics of synthetic aperture radar (JERS, Radarsat and Envisat), Landsat and MODIS data are the basis for our studies. Field measurements of phenological changes in aquatic macrophyte biomass near Manaus and Santarem provide a basis for calibrating radar images to estimate productivity of aquatic macrophytes. Field measurements of methane emission in the interfluvial wetlands of the upper Negro basin complement previous studies in the central Amazon basin. These remote sensing and field analyses are being integrated into regional modeling of carbon dioxide and methane emissions.

4.6: Numerical and observational analysis of the Amazon River flood cycle 1939-1998

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In this paper we validate and analyze the hydrology of the Amazon River system as simulated by a significantly improved model of terrestrial hydrology (Terrestrial Hydrology Model with Biogeochemistry, THMB). Model improvements include: 1) representation of the basin topography with the Shuttle Radar Topography Mission DEM, 2) incorporation of river sinuosity data to calculate river flow length, 3) derivation of flood initiation height and volume based on data from 287 sites, 4) calculation of river and floodplain flow velocity based on the Chezy formula, and 5) integration of river and floodplain reservoirs within THMB to include the floodplain in the water yield calculation.

We evaluate the simulated time-transient floodplain inundation of the Central Amazon basin against observations of river discharge, floodplain inundation, and water height and analyze the spatial and temporal variability of the hydrology for the period 1939-1998. Model simulated floodplain inundated area is improved compared to the simulations by Coe et al., 2002. The coefficient of correlation between the simulated and Sippel et al., 1998 estimate of mean monthly flooded area exceeds 0.8 for many of the mainstem reaches. Additionally, comparison to data recently available from Hess et al., 2004, indicates good agreement of the spatial distribution of wetlands in the Central Amazon basin. Analysis of the time-transient flooded area confirms that the long (28 year) and short (3-4 year, ENSO) modes of variability in the precipitation strongly influence the variability of the flooded area. This variability has important implications for the biogeochemical cycles of the Amazon basin.

4.7: Inter-annual Variability in Large-Scale Flooding of Aquatic Ecosystems and Associated CO_2 Evasion in Amazonia: A Modeling Strategy

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The inter-annual variability of flooding in the Amazon basin is a major determinant of the spatial and temporal distribution of regional aquatic ecosystems and their associated CO_2 fluxes and ecosystem services. To date, excellent static remote sensing images showing the distribution of aquatic ecosystems at high and low water in 1995-6 have been produced that differentiate among ecologically and biogeochemically distinct categories for the basin (e.g., permanent open water, seasonally and permanently flooded vegetation) (Hess et al. 2003). However such a resource does not exist for a multi-year time series.

To produce this key information, we apply a physically based modeling system to simulate hydrological fluxes and aquatic CO_2 emissions throughout the basin as a function of vegetation cover and time-transient climate. This modeling system includes an ecosystem land surface model (IBIS), a Terrestrial Hydrology Model with Biogeochemistry with dynamic floodplain (THMB, formerly HYDRA), and an aquatic C processing module that we are incorporating into THMB (Howard et al. in prep). THMB represents river discharge and flood extent and height throughout the Amazon Basin (Costa et al. 2002, Coe et al. in prep). It has been calibrated and validated with observations of river discharge, water height, and flooded area at numerous locations in the mainstem and headwaters.

In order to simulate how the areas of particular aquatic ecosystems change over time, we fused the sub-grid scale classification of ecosystem distribution from Hess et al's single-year, classified remote sensing data (2003) with our simulation of seasonal and inter-annual hydrological variability. We will also discuss our efforts to use these multi-year simulation results, along with current observations of C fluxes from different ecosystems, to extrapolate and bound overall estimates of net CO_2 efflux from the Amazon River system.

Parallel Oral Session 2

2A: Aquatic Biogeochemistry

5.1: Emissions of CH4 from interfluvial, savanna wetlands bordering the upper Negro River

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Amazon wetlands have been shown to be a globally significant source of methane to the troposphere. However emissions from many wetland habitats have not been adequately characterized. Here we present data on the seasonal patterns of flooding and

methane emissions in interfluvial, savanna wetlands bordering the upper Negro River, a regionally important but as yet unstudied wetland habitat. Water levels and rainfall were measured continuously at two study sites from December 2005 to August of 2005. Diffusive emissions and surface water concentrations of CH4 were measured monthly at both sites during the same period. Diffusive emissions were measured during short-term incubations with a static chamber and surface concentrations were estimated with the "headspace method". Methane concentrations were determined by gas chromatography. The wetlands at both sites remained flooded during most of the year with water levels varying in response to changes in rain fall and water table levels. The average emission rate for the study period was 21 mg CH4/m2/h (SD = 43). The average surface water concentration of methane was 48 mg CH4/l (SD = 140). Emission levels were highest at high water levels and tended to be greater in flooded grasslands than in open water environments.

5.2: Key Connections in Amazon Stream Corridors: Using ^{15}N to Trace N Transformations and Transport

Linda Ann Deegan, Marine Biological Laboratory, ldeegan@mbl.edu (Presenting)

Small streams act as important sites in the landscape where nutrients arriving from adjacent uplands are retained, transformed, or released to larger rivers. Our work focused on determining the effects of land use change on nutrient storage, export and transformation in streams draining forest and pasture using solute injections to examine the fate of N and P and ^{15}N tracers to examine the retention and export of N. We found that the uptake lengths for NO_3^- and PO_4^{3-} were shorter in pasture streams compared with similar forest streams. We conducted three ^{15}N additions (1 in forest; 2 in pasture streams) to determine how land use alters the stream N cycle, such as uptake by microorganisms and nitrification, and ultimately how the balance between storage and export is affected. The forest stream exported N, mostly in inorganic form (87%), while the same size pasture stream (2nd order) was highly retentive of N, storing almost 88%, primarily in the riparian grasses, and exporting less than 15% predominately as suspended particulate N. The larger pasture stream exported approximately the same percentage of N (85%) as the forest stream, but the export was divided equally between inorganic forms (NH_4^+ and NO_3^-) and particulates. Riparian grasses in the larger pasture stream stored little N. Our ^{15}N additions indicated that replacing forest with pasture led to large differences in stream biogeochemical transformations and export. The overall effect of this change was to make small pasture watersheds more retentive of these nutrients than the original forested watersheds.

5.3: Controls on stream DOC flux and composition in the Amazon region, Tapajos national forest

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To improve predictive capabilities of water, carbon and nitrogen gas fluxes in the Amazon region, we are examining the influence of land cover, topography and soil on stream dissolved organic carbon (DOC) flux and composition. Using 90-m SRTM digtal elevation (DEM) data and land cover/land use maps derived from Landsat-TM we have selected several catchments in the Tapajos national forest drainage area with contrasting land use, topography, and soils. Field sampling of throughfall, lysimeter and stream water components will provide insight into flow path dynamics and a better understanding of the chemical nature of DOC under contrasting land use patterns. In addition to parameterizing model simulations of carbon and nitrogen dynamics, monitoring of DOC flux across select streams will be used for model validation.

5.4: Soil properties determine fluvial losses of carbon in Amazonian headwaters

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Soil properties were found to be pivotal in their control on surficial as well as subsurface flow paths of carbon (C) and export with streamwater. Soil texture provided a first-order control on the activation of hydrologic flowpaths, and thereby fluvial processes that affect ecosystem functioning. A larger increase in clay content with depth for an Ultisol-dominated watershed resulted in a significantly greater percentage in storm-related quickflow compared to an adjacent Oxisol dominated watershed (3.2 ± 0.2% of event precipitation, compared to 2.5 ± 0.3 %). Although small, these quickflow volumes correspond to large dissolved organic C (DOC) fluxes as soon as rainfall starts. Whereas DOC dominated surficial flowpaths, baseflow dissolved C for both soil formations was found to be predominantly in the form of dissolved CO2. That storm events produced a CO2 pulse in stormflow indicates that high CO2 pre-event water forms a significant component of stormflow. This was corroborated using other environmental tracers in combination, such as the K:SiO2 ratio.

5.5: Human exposure to mercury as a consequence of deforestation by slash-and-burn agriculture in the Amazon.

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A participatory and interdisciplinary research on mercury contamination in aquatic resources unfolded in the Brazilian Amazon over

the last 10 years. It allowed to identify deforestation and soil erosion as the main source of mercury away from gold mining zones and to witness early health alterations in riparian communities related to consumption of Hg-loaded fish. Deforestation of this area is based on slash-and-burn agriculture, which displaces Hg from soils through the sudden and large input of cations stored in the forest biomass. These results were found on old weathered Oxisols and Ultisols that accumulated Hg for millions of years. On an other research site located in the Amazonian Ecuador, a similar high soil Hg content was found, especially for Andisols. Although geologically younger than soils from the Brazilian Amazon, nearby volcanic activity had an influence of Hg deposition from atmospheric inputs. We are now using our scientific findings along with a bottom-up approach with pilot communities to realize intervention and empowerment projects. Such projects aim at short-term improvement of human health (shift in food consumption patterns) and long-term restoration of the environmental equilibrium (slow-down of deforestation with a shift to more sustainable agricultural practices). The scaling up of our activities from a series of pilot projects to a concerted regional intervention at the scale of an entire watershed is presently underway with the creation of an ambitious network regrouping representatives of local communities, stakeholders from local, state and federal governmental institutions, and key decision makers of international organisms.

2B: Explaining Land Use

6.1: Road Investments, Spatial Intensification and Deforestation in the Brazilian Amazon

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Anticipating the impacts of new roads on environmental services is crucial for the complete evaluation of these major investments in infrastructure. Using a regression model and a large suite of explanatory variables, we find that deforestation rates in the Brazilian Amazon increase in census tracts lacking roads but within 100km of a tract with a new paved or unpaved road. We provide mixed evidence of reduced clearing in census tracts lacking roads between 100km and 200km from tracts with roads, and at greater distances paved roads are found to increase deforestation. Alongside the finding in Pfaff et al. 2005 that any new road investment unambiguously increases deforestation within census tracts with roads, our results reject the recent claim that such road investments will reduce a county's deforestation rate by spatially concentrating development in fewer tracts. In addition to presenting the regression findings on roads, we demonstrate that this methodology yields projections of deforestation based on scenarios, and that it can compare projected deforestation to observed deforestation as well as to outputs from other models.

6.2: Roads and Deforestation in the Amazon Basin

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Road building in tropical forest regions has become an increasingly contentious issue given the importance of roads to economic development and possible environmental impacts. The Brazilian Amazon is often cited in this regard, where rapid expansion of the region's highway system is linked to waves of in-migration and persistent deforestation that began with the opening of the Belém-Brasilia Highway in 1968. Despite the seemingly obvious proposition that roads cause deforestation, some researchers have called attention to the fact that links between deforestation and transportation infrastructure might be more complicated than they appear, prima facie. A more nuanced discussion is emerging which suggests that hidden factors affect the placement of roads and the magnitude of deforestation simultaneously, and that road building itself may follow from deforestation. This paper seeks to identify circumstances in which roads cause deforestation in the Amazon basin by addressing the road-deforestation relationship. In so doing, it considers circumstances in which causal processes are less straightforward. In pursuing these twin objectives, the paper (1) identifies parts of the Amazonian transportation system that may be regarded as causal to deforestation, and (2) presents empirical evidence for situations in which the road-deforestation relationship shows a more complex pattern of cause and effect. The paper concludes with policy implications.

6.3: Modeling soybean expansion into the Amazon Basin

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In the last decade, industrial agriculture has become one of the main economic forces driving the expansion of the agricultural frontier in the Brazilian Amazon, led by soybean production. Between 1990 and 2003, soybean production grew from 3 to 14 million tons/year and the area planted increased from 16,000 to 47,000 km2. This expansion has been stimulated by several factors, including growing international demand, devaluation of the Brazilian Real, improvements in infrastructure, and the development of soybean varieties suited to Amazonian climate.
The future expansion of soybean production into the Amazon is still unknown. Here, we present a model of soybean yield that integrates the major climatic, ecological, economic, and spatial determinants in the Amazon Basin. Yield is modeled as a function of: Soybean Physiology Model that captures the effects of climate and physical attributes on the development of soybean plant; fertilizer applications; and economic/spatial parameters such as transports costs and latitude. The results indicate that climate, physical attributes, and economic parameters can account for about 45 percent of the spatial variation in yield. We estimated that roughly 20% of Amazon Region or ~ 1,000,000 km2 (excluding protected areas) has potential to raise soybean crops with yields greater than 2,000 kg/ha. Mato Grosso State, the largest soybean-producer of Brazil, shows high soybean potential with an area estimated of ~ 475,000 km2.
The hybrid model provides a mathematical and cartographic framework that the scientific community and policymakers can use in their efforts to maximize the benefits from soybean economic activity while minimizing its negative externalities for Amazon economies and ecosystems.

6.4: Nexus between socioeconomic dimensions, population movements and deforestation in the Brazilian Amazon

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The incorporation of the human dimensions into models of deforestation still represents a great challenge. Given the complex nature of interrelationships, it is difficult to distinguish effect from cause as well as to measure quantitatively the influence of socioeconomic drivers. We present a spatial econometric model of deforestation for the Brazilian Amazon that analyzes the influence of a series of socioeconomic and demographic variables selected from IBGE 1996 and 2000 censuses, as well as other economic and social surveys carried out within 1996-2000 period. This data set includes for each Amazon county the variables: proximity to paved roads and urban centers, cattle herd, agricultural production, income per capita from agriculture, percent of agriculture land, total population and rural population density, urbanization level, migratory volume, net migration rate, agrarian infrastructure and concentration indices, gross domestic product, social development index, and percent of protected area. The model consists of three spatial lag regressions. The first two employ, as response variable, the percent of deforested land in 1997 and 2001, obtained from PRODES for 630 Amazon counties, and the third regression assesses the effect from changes in the socioeconomic context on the 1997-2001 deforestation rates of 399 counties. After spatial autocorrelation removal and heteroskedastic control, the two first models achieved R^2 above 8.7, while the third obtained 6.9. Proximity to paved roads, cattle herd, and population density (both rural and total) were the most important variables to explain stocks of deforested land, while increase in cattle herd and migratory volume related most closely with the deforestation rate. Worthy of mention, social development and percent of protected area were the only variables to present a negative correlation with stocks of deforested land. In conclusion, the obtained spatial econometric model provides a means to establish a chain of cause and effect and thus can be used to infer the potential for future deforestation from changes in the socioeconomic and demographic context, not only within a specific Amazon county, but also from its neighboring regions.

6.5: Trajectories of Land Use in the Brazilian Amazon: evidences from satellite imagery and Census data

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Amazonian satellite imagery show concentration of forest clearing near major roads where landscapes tend to be dominated by pastures. Census data confirm the dominance of pastures, revealing that the fraction of land used as pasture and the stocking rates increased, while the fraction of crops and unused land declined. Census municipal data suggest that the increase in the relative importance of pasture and the decline in the fraction of crops and unused land may imply unexplored trajectories of land use with consequences to the LBA agenda, if effects of land-use intensification and/or land degradation on nutrient and carbon cycling are considered. In fact, municipal level data suggest that the increase in stocking rates may be explained by such increase in 'municipios' with less forest fractions; the decline in the relative crop importance may have been accompanied by specialization in some older settlement areas where crop importance actually increased; and the decline in the fraction of unused land may be explained by its decline in areas with less forest fractions. Although comparison of the 1985 and 1995/96 Censuses requires caution, the results suggest a pattern of land-use intensification in areas with higher rates of deforestation, resulting in larger outputs from both cattle ranching and agriculture. Such evolution is apparently corroborated by the consolidation of market chains such as beef, dairy and grains, that may motivate intensification and, possibly, increase forest clearing. A hypothesis to be tested

is the existence of a threshold when forest conversion lead to land-use intensification.

6.6: Migration and LCLU in the Ecuadorian Amazon

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Migration has been a neglected topic in studies of population-land use interrelationships in frontier areas in the Amazon basin as well as elsewhere. This paper will take a broad view of the linkages between migration and the striking changes in the landscape in the northern Ecuadorian Amazon (NEA) over the past three decades. Our discussion is divided into four parts. First, we provide an overview of the effects on LCLU of the discovery of petroleum near Lago Agrio in 1967 following the construction of roads and oil pipelines to move the oil across the Andes for export. This led to massive in-migration of agricultural colonists in search of land, beginning in the 1970's and continuing to the present, albeit at a lower level. This will draw upon data from the four population censuses from 1974 to 2001. Second, we will examine the process of in-migration and colonization of the NEA in more detail based on data from a longitudinal survey of colonist families and farms carried out in the region in 1990 and 1999. We indicate where the migrants to the Amazon are coming from, why they are leaving their areas of origin, and why they are choosing the Amazon destination, to the extent possible from the available data. The third part focuses on a key issue not investigated in previous studies of agricultural colonization at the frontier in other sites: what happens to the people and their use of the land subsequently, that is, what does the next generation do--stay on the farm, move to towns in the region, move to other rural areas in the region creating new farms and a further wave of forest clearing, or return to the origin areas outside the Amazon? Each of these has different implications for the environment, including LU. Data from the longitudinal survey and a linked survey of community leaders in 61 communities will be used to investigate these subsequent processes of population redistribution, including urbanization and further extensification of agriculture. For this, statistical models, including multilevel models, will be used to investigate the determinants of migration decisions of members of colonist households. Lastly, the paper will conclude with policy implications and suggestions for further research, in Ecuador and more generally in the Amazon context.

6.7: Modeling Deforestation and Agricultural Extensification in the Ecuadorian Amazon: Approaches for Integrating People, Place, and Environment in the Study of LCLU Dynamics

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Relying upon a longitudinal socio-economic and demographic survey of colonists (1990 & 1999), a community survey (2000), a remote sensing image time-series (1973-2003), and GIS coverages of resource endowments and geographic accessibility, land use/cover dynamics are examined in the northern Ecuadorian Amazon. Among the fundamental questions being examined through various modeling approaches include: What are the rates, patterns, and mechanisms of forest conversion to agriculture, pasture, secondary forest succession, and urban uses?; and What are the plausible scenarios of future land cover change and their policy implications? To address these questions, our land use/cover studies have used different modeling approaches, to examine: (1) changes in forest fragmentation at the farm-level using Generalized Linear Mixed Models, (2) proportion and change of secondary forest at the farm level using Spatial Lag Models, (3) community effects on land use/cover patterns at the farm level using Multi-Level, Constrained, Fixed Effects Models, (4) land tenure and deforestation in protected areas using Neutral Models, and (5) land use/cover change patterns through spatial simulations using Cellular Automata and Agent-Based Models. All these models and simulations are described relative to their capability of incorporating spatial and temporal dynamics; the effects of spatial autocorrelation; non-linear systems with feedbacks that integrate people, place, and environment; the effects of multiple stakeholders on land use/cover dynamics, and policy implications of land use/cover change in the northern Ecuadorian Amazon for historical, contemporary, and future periods.

2C: Biomass and Necromass

7.1: Estimating Aboveground Forest Biomass Using Geostatistics Techniques: a case study of Rondônia, Southern Brazilian Amazon

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Mapping aboveground forest biomass is of fundamental importance for estimating CO2 emissions due to land use and land cover changes in the Brazilian Amazon. Existing biomass maps for this region diverge in terms of the total biomass estimates derived, as well as the spatial patterns of mapped biomass. In addition, no regional or location-specific measure of reliability accompanies most of these maps. In this study, 330 one-hectare plots from the RADAMBRASIL survey, acquired over and along the adjacent state of Rondônia, were used to generate a biomass map over the entire region using geostatistics. Topography, vegetation type and soil texture were used as biomass predictor variables with simultaneous estimation of: (i) the parameters of a linear regression of biomass, and (ii) the residual biomass variogram model, using maximum likelihood fitting. The fitted variogram model indicated a strong spatial correlation up to 100 km, which decreased gradually after that distance to become negligible beyond 300km. The RADAMBRASIL samples were used to generate a map of biomass, along with a measure of reliability for each biomass estimate at each location, using Kriging with External Drift. Cross-validation was performed using the sample plots to compare the performance of Kriging against the biomass estimation using the sample mean. The cross-validation results showed that Kriging generated more accurate estimates of biomass, outperforming the sample mean estimation by 5%. Additionally, the Kriging method captured the spatial distribution of biomass and provided a measure of uncertainty for local estimation. Overall, the biomass varied from 156 to 600 Mg.ha-1, with a local standard deviation ranging from 60 to 300 Mg.ha-1. Large uncertainties were obtained for regions with low sampling density, in particular in savanna areas. These methods have the potential to be applied over the entire Brazilian Amazon region to provide more accurate local estimates of biomass, along with measures of their reliability to identify areas where more sampling efforts should be concentrated.

7.2: Carbon dynamics in coarse woody debris pools at the Tapajós National Forest in Brazil

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The dynamics of coarse woody debris (CWD) pools in tropical forests is poorly understood. Within temperate and boreal biomes, environmental factors have been strongly correlated to variations in rates of emissions of CO_2 from CWD. CO_2 emissions were measured in an undisturbed old growth forest and an old growth forest under selective logging. In the logged area three tree species (*Manilkara huberi*, *Couratari stellata* and *Carapa guianensis*) were chosen to be examined due to differences in their initial wood densities. In the undisturbed area, the rates of decomposition measured as CO_2 emissions were 1.54±1.32 (mean±s.d.) μmol $m^{-2}_{\ wood\ surface}\ s^{-1}$ with the least decayed wood fragments showing the highest emissions. In the logged area, the average flux was 3.22±3.09 μmol $m^{-2}_{\ wood\ surface}\ s^{-1}$. The three tree species showed average fluxes of 3.69±3.57, 1.96±1.6, and 3.91±3.17 μmol $m^{-2}_{\ wood\ surface}\ s^{-1}$ for andiroba (*Carapa guianensis*), maçaranduba (*Manilkara huberi*) and tauari (*Couratari stellata*), respectively. CO_2 emissions were strongly seasonal because of the variation in wood water content especially in diameter classes below 10 cm. We also found that annual emissions were correlated positively with wood fragments diameters. Large fragments remained moist throughout the year supporting high emissions whereas small diameter debris showed greater variation in moisture content and CO_2 emission.

7.3: Long-term experimental drought effects on stem mortality, forest structure, and necromass pools in an Eastern-Central Amazonian forest

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Severe drought stress provokes dramatic changes in plant mortality, and on the structure and carbon dynamics of moist tropical forests. In this study, we report on the long-term shifts of forest structure and stem mortality (trees, lianas and palms ³2 cm dbh) in the east-central Amazon Basin following four years of drought imposed through a large-scale throughfall exclusion experiment. Fifty percent of incoming precipitation was prevented from entering the soil in the 1-ha dry plot (D) during the 6 month wet season using a system of 5,660 plastic panels located in the forest understory, while a paired 1-ha wet plot (W) received normal rainfall. The treatment provoked a 38% elevation in community wide mortality rates, 2.72% yr-1 (W) and 3.77 % yr-1 (D). Large trees, ³30 cm dbh, underwent drastic increases in mortality (W=1.74% yr-1, D=9.47% yr-1; P=0.005), while small stems (2-5 cm dbh) were relatively unaffected (W=2.77% yr-1, D=3.16% yr-1; P=0.126). Recruitment rates did not compensate for the increased mortality in the larger stem classes of the D plot, resulting in ~10% annual reduction of total stems in the size classes >10 cm dbh. Mortality rates of woody lianas were more strongly impacted by drought (W=3.78% yr-1, D=6.78% yr-1; P=0.004) than trees or palms; and mortality rates of canopy tree species significantly increased (W=1.75, D=3.80; P

7.4: Spatial and Temporal patterns in Carbon Storage in Live and Dead biomass across the Tapajos National Forest and the BDFF plots in Manaus.

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Amazon forests are potential globally significant sources or sinks for atmospheric carbon dioxide. Quantifying large-scale vegetation and disturbance patterns in such forests allows extrapolation of local measurements in old-growth forests to landscape and regional carbon balances. To examine dynamics of carbon storage in an Amazonian forest, we assessed coarse woody debris (CWD) stocks, tree growth, mortality, and recruitment over a period of 6 years across 20 ha in the footprint of an eddy covariance tower at km 67 in the Tapajós National Forest (TNF) near Santarém, Pará, Brazil. From 1999 to 2005, standing live biomass has shown small carbon accumulation and a large measured pool of CWD, suggesting possible disturbance recovery. To characterize carbon dynamics in live and dead biomass pools at the landscape scale, we surveyed 40 ha distributed more widely throughout the TNF (4 x 10ha plots). The plots at km 67 appear to be representative of the greater TNF, with similar stocks of CWD and overall standing biomass. Relative to the Biological Dynamic of Forest Fragments (BDFF) plots, near Manaus, CWD at the TNF was almost double (116.7 m^3/ha at TNF, 60.13 m^3/ha at BDFF), while live biomass was similar (155.4 ± 7.0 MgC/ha at the TNF, 167.8 MgC/ha at BDFF). However, a closer examination of the distribution of live tree biomass across size class reveals that large trees make up a larger proportion of total standing live biomass in the TNF. This pattern of higher CWD volume and more uneven size distribution in the forest is consistent with inferred higher rates of disturbance in the TNF than at the BDFF site.

7.5: Impacts of Amazon Forest Fragmentation on Floristic Composition and Carbon Storage

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Large expanses of Amazonian forest are being cleared and fragmented each year, but the impacts of habitat fragmentation on diverse Amazonian plant communities are poorly understood. I summarize findings from a long-term (26-year) experimental study of tree-community composition in fragmented and intact forests in central Amazonia. Results are derived from 40 1-ha permanent plots that were repeatedly sampled before and after fragment isolation. Within these plots, trajectories of change have been assessed for 267 genera and 1162 individual tree species. Rapid shifts in floristic composition are being driven by sharply accelerated tree mortality within ~300 m of fragment margins, causing population declines of many large-seeded, old-growth taxa, especially for larger (>60 cm diameter) trees. Disturbance-tolerant species, such as pioneer trees and lianas, are rapidly increasing. Pioneer and successional trees tripled in abundance in the first 1-2 decades after fragmentation, and are continuing to increase over time.
As a result of these changes, habitat fragmentation is fundamentally altering carbon storage and dynamics in Amazonian forests. The rate of carbon cycling probably increases sharply, both because long-lived canopy and emergent trees decline in favor of shorter-lived successional trees and lianas, and because necromass production and turnover both increase. Carbon storage in live vegetation also declines because small successional trees and lianas (which typically have low wood density) store substantially less carbon than do large, old-growth trees. The decline and rapid decay of live biomass in forest fragments may produce substantial atmospheric carbon emissions, above and beyond that resulting from deforestation per se.

7.6: The age of the DBH

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A basic understanding of tree population dynamics is required for predicting the potential role of tropical forests as carbon sources or sinks, as well as for local design of sustainable extractive management practices. In order to understand how long small trees need to attain 1.3 m height we use radiocarbon to dating the center of the stem base and the center of the DBH from small trees. Sampling was done in three locations spanning the Brazilian Amazon basin. We sampled all trees < 10 cm DBH in randomly selected plots of 6.9 m2 (2.5 x 2.5 m) of intact forest and recent gap in Manaus (AM), Santarém (PA) and Rio Branco (AC). Preliminary data showed that ~ 50% of trees need more than 50 years to attain 1.3 m in intact forests from every site. In spite of trees in recent gap areas need less time to attain 1.3 m than in intact forests, we found in more than 20% of the trees the pattern observed in intact forests. These new findings have important implications for tropical forest management and carbon cycling.

7.7: Carbon dynamics in trees, litter, and soils - a comparison of three forests

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We used a combination of measures of C stocks, fluxes, and isotopic tools to study the amount and residence time of C in forests at LBA sites in Acre (Cautaba Reserve), Manaus (ZF2), and Para (FLONA Tapajós). In both vegetation and soils, the age of C in standing stocks (200-300 years for trees, hundreds to thousands of years for C in mineral soils) is longer than the mean residence time of C (50-150 years for trees, years to decades for soils). C cycling in vegetation is slowest in the Manaus site, and more rapid in more open forests in Para and Acre. The age of C respired from soils reflects the importance of root/rhizosphere respiration and rapid decomposition of older root and leaf litter. Modeling of C stock changes in Amazon forests given scenarios of logging, fertilization or interannual variations in net ecosystem production need to account for the time lags between photosynthesis and respiration.

Parallel Oral Session 3

3A: Fire

8.1: Fire characterization in the Amazon using multi-scale, multi-spectral satellite measurements

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Improved sensor capabilities and advances in scientific knowledge have enabled the characterization of individual fires from satellite measurements. In this study, fires in the Brazilian Amazon, mapped previously by conventional active fire detection and burned area products, were further analyzed to explore the potential for a more comprehensive characterization of the burning process. Intensities of active fires were characterized by the Fire Radiative Power (FRP), while burn severity was assessed by the differential Normalized Burn Ratio (dNBR) from pre- and post-fire multispectral imagery. FRP values were derived from 1km MODIS (Moderate Resolution Imaging Spectroradiometer) measurements on Terra and Aqua. To analyze the FRP signal, we then used coincident 30m resolution active fire maps from the Terra/ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) sensor to determine the more precise location of the active fire front and to correct MODIS FRP values for the uneven sensitivity of the MODIS sensor to radiant intensity within the pixel. Maps of dNBR for the same fires were derived from pre- and post-burn ASTER and MODIS imagery. The information content of FRP and the relationship between FRP and dNBR were then analyzed to demonstrate the potential and limitations of these remote sensing products to determine the type of fires observed. In this analysis results from ground observations of fuel loads, fire temperatures and residence times from previous field work within the LC-23 project were also used to explain the variation of FRP and burn severities.

8.2: Wildfire in the Amazon's transitional forest: Initial effects on stem mortality, canopy structure, and microclimate and consequences for future fire susceptibility

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The Amazon's transitional forest extends along the southern edge of the basin, where increasing ignition sources and a conducive climate are resulting in widespread forest fires. We describe the fire behavior and initial damage and tree mortality from one square kilometer of burned forest in Mato Grosso, Brazil - one of the largest experimental fires in the tropics. Average flame heights of the first experimental fire, set in August 2004, were 30 cm and the average spread rate was 14 m hr-1. This low-intensity fire burned near 80% of the 100-ha test area. Direct fire damage caused greater immediate stem mortality in the smallest size classes. Area-wide more than 50% of seedling stems and 25% of tree stems ≤ 5 cm diameter at breast height (DBH) died during the fire or in the first few weeks after, compared to 12% and 1%, respectively, in the control plot. One year after the fire only 6% of larger stems, ≥ 10 cm DBH, died in the burned plots compared to 2% in the control plot. We expect, however, that many larger stems will die in the upcoming years. These creeping understory fires also change canopy structure. Immediately following the fire, litterfall in the burned plots was 1.9 versus 0.5 g m-2 d-1 in the control plot, more than three times higher. Nine months post-fire, leaf area index (LAI) in the burned plots was 3.7 versus 4.3 m2 m-2 in the control plot, a difference of 10%. The consequent increase in fuel loads through mortality and leaf shedding, structural opening of the canopy, and resulting changes in understory microclimate increase future fire susceptibility. Predictions of more severe climatic shifts and the rapidly expanding agricultural frontier make understanding how fire influences this ecosystem key to its preservation.

8.3: Improving potential biomes allocation by considering fires in savannas

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Because fires have strong effects on biogeochemical cycles and important relations with dominant characteristics of the land surface, it is important that biome models are able to account for fire occurrence. To this end, the CPTEC-PBM (Brazilian Center for Weather Forecast and Climate Studies - Potential Biome Model) is being improved to account for fire activity. We have begun by considering regions of savannas, where fire activity is highest and fire effects are particularly important. As shown by satellite-based data, the global patterns of fire occurrence and savannas are very similar. Compared to the relatively slow processes of vegetation carbon uptake and growth, fast mortality and biomass consumption by fires may favor grasses and reduce trees coverage. In order to account for large spatial and temporal patterns of natural fire occurrence in savannas, we have made two main assumptions. First, lightning is the most important source of ignition for natural fires. Second, over continental areas in the tropics, lightning is mainly related to the zonal flux of humidity. The parameterization of fire occurrence in savannas was then built on a simple empirical relation based on combined information on average and intra-annual variance of the zonal wind. The implementation of this new relation improved the formulation and the results of the CPTEC-PBM. In particular, the accuracy allocating major biomes in India and Southeast Asia is substantially higher than in previous results.

8.4: Numerical Simulation of Biomass Burning Emissions and Transportation during 1998 Roraima Fires

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We study the atmospheric transport of carbon monoxide from biomass burning that took place during the early months of 1998 in Roraima. Due the activity of the 'El Niño' atmospheric phenomenon, the vegetation fires occurred with a remarkable intensity. We focus on the role of deep convective systems on the 3d CO redistribution using the Eulerian approach for CO mixing ratio determination.
The simulation is carried out using the system CATT-BRAMS (Coupled Aerosol and Tracer Transport model to the Brazilian developments on the Regional Atmospheric Modeling System). In this method, the mass conservation equation is solved for carbon monoxide (CO) in-line with the atmospheric model equations. Source emissions of gases associated with biomass burning activities in are parameterized and introduced in the model. The daily burned area estimate is obtained through a normalization of the total burned area using the TOMS Aerosol Index. We also used a convective parameterization with training capability in order to improve the representation of the involving deep convective systems in the model.
Model results are compared and validated with data collected during the LBA-CLAIRE-98 campaign. The flight 8 over Suriname on March 26, detected at high altitudes (> 9km) a layer of air mass with chemical composition characteristic of aged biomass burning smoke over a clean air column. The numerical simulation was able to reproduce the observed CO profile and could explain the main transport mechanisms involved.

8.5: Atmospheric deposition and nutrient fluxes in Amazonian: from natural biogenic aerosols to biomass burning impacts

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Atmospheric pollution and other human activities have altered natural nutrient cycles over large regions of the world. The atmospheric deposition of chemical species within the Earth's ecosystems not only provides a natural sink but also acts as a source of nutrients and plays an essential role in controlling the biogeochemical cycles such as of carbon, nitrogen and phosphorus. Amazonian is one of the few terrestrial ecosystems on Earth where during the wet season it is still possible to observe the functioning of an ecosystem relatively undisturbed by anthropogenic activities. In some of these regions, atmospheric aerosols appear to be an important, if not dominant, source of new phosphorus inputs while wet deposition is the dominant source of nitrogen and carbon inputs to the Amazonian ecosystem. Here, we use recent measurements of atmospheric deposition (rainwater

and aerosols) to show that the Amazon Basin itself appears to be a substantial source of atmospheric nutrients as a consequence of biomass burning emissions, anthropogenic sources of mineral aerosols and primary biogenic particles. Observations suggest that biomass burning emissions is responsible for changes in the N, C and P fluxes in the Amazonian. These changes can drive a 2-3 fold increase in the atmospheric deposition of N and C. Our results pointed out that the composition of rainwater and aerosols in disturbed areas appears to be controlled mostly biomass burning while in the remote areas biogenic and marine emissions are the dominant sources. Moreover, the pattern of organic acids in the atmosphere also has changed due to biomass burning. These large perturbations to the tropical biogeochemical cycles have important consequences for ecosystem functioning. Although biomass burning may bring new nutrients into non-disturbed regions, as a whole the Amazon appears to be losing nutrients such as phosphorus through the atmosphere.

3B: Amazon Futures

9.1: Assessing ecological and economic trade-offs of alternative land use policy scenarios for the Xingu River headwaters region

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The rapid expansion of agro-industry in the southeastern Amazon is driven by increasing links to global food commodity markets. Environmental legislation designed to regulate the impact of this growth in the agro-industrial sector has met with limited success. To begin identifying potential policy modifications and other mechanisms to encourage environmental protection on private lands, we developed alternative scenarios to analyze the ecological and economic trade-offs of proposed changes to current Brazilian land use legislation for the Xingu River headwaters region (northeastern Mato Grosso state). We compared a baseline scenario (based on current land cover maps) (1) to a landscape that assumes perfect compliance under current requirements (under which landowners are required to maintain 80% of their land in a legal reserve if the property is located inside the Amazon forest biome), and (2) a landscape assuming a reduction in the legal reserve to 50% (proposed by local producers). The maps were used to evaluate each scenario's impact on ecological (e.g., habitat fragmentation, water quality, carbon emissions) and economic (e.g., rent, employment) indicators. We also assessed the likely costs for restoration of riparian zones and legal reserve areas to meet (1) current legal requirements and (2) those of other proposals. Furthermore, we estimated the necessary price per ton of carbon on the international market (1) to compensate landowners for the opportunity cost of maintaining land in forest and (2) to off-set the costs of forest restoration. We also assess the qualitative costs and benefits for different stakeholder groups in the region.

9.2: Scenarios of land-use change applied to the ecological-economic zoning of state of Acre, Brazil

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We present a method to evaluate the land-use zoning delineated by government of Acre for its territory during the first phase of the State ecological-economic zoning project. The method employs a landscape simulation model to prognose future land-cover changes under different scenarios of land-use regulation and recommendations and applies the simulation outputs to assess environmental outcomes likely to occur over the scenario trajectories. This study area encompasses a tract of land along Br-317 highway centered on Brasiléia county. The initial land-use map is a composite of a map produced from participatory mapping, which incorporated the local inhabitants' perception about their territory, and deforestation series from PRODES; it comprises 6 land-use classes (forest, logged forest, pasture, annual agriculture, permanent agriculture, and regrowth) that can generate 21 transitions. Three scenarios were developed; the business-as-usual scenario depicts the traditional evolution of the Amazon frontier, reproducing the phases of initial settlement, when subsistence agriculture represents the major economic activity, decline of agriculture, followed by exodus to urban areas, and replacement by large cattle ranching with consequent agrarian concentration. The two alternative scenarios incorporate the land-use recommendations established by the ecological-economic zoning project for Acre state territory and the third also includes land-use restrictions determined by the Brazilian forest code. Whereas deforestation and logging follow the historical pace in the first scenario, the other two assume a declining deforestation trajectory and sustainable logging. All scenario assumptions were translated into the simulation software - DINAMICA - by using its modeling resources. After calibrating the model with historical data, we run each scenario for 36 years, starting in 2004. The model outputs allowed us to identify the most vulnerable areas around Chico Mendes reserve as a result of the deforestation trend and the proposed land-use zoning as well. The comparison of the two alternative scenarios demonstrated that the strict abidance of the forest code may lead to a more fragmented landscape. These results illustrate the usage of simulation modeling as a tool for environmental planning. Current investigations, involving hydrological impacts, habitat fragmentation, and agriculture/extractive revenues, are being undertaken employing the simulation outputs.

9.3: The Role of Private Forest Reserves in Biodiversity Conservation in the Brazilian Amazon

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Daniel Curtis Nepstad, Wooods Hole Research Center & Instituto de Pesquisa Ambiental da Amazonia, dnepstad@whrc.org

In the Brazilian Amazon, the total area of legally-required forest reserves on private properties is approximately 600,000 km2, three times larger than the Amazon's protected area system. These areas are important for maintaining forest corridors and protecting streams and rivers throughout the basin, but are assumed by many conservationists to have little value for biodiversity conservation. In northeastern Mato Grosso state, Brazil, where deforestation rates are increasing due to the rapid expansion of mechanized agriculture and cattle ranching, these reserves are likely to be critical for maintaining local biodiversity. To test this prediction and to gather field data for simulation modeling of mammals in agricultural landscapes, we are sampling mammal species composition and abundance in riparian forests and terra firme forest on an 82,000 ha soy bean ranch, of which over 50% is maintained in forest. We employ automatic cameras, visual census, and animal tracks. We recorded 30 mammal species—almost the full complement of large mammal species expected for this habitat. Some of these species have not yet been confirmed so far south in the Amazon basin, including the endangered white-whiskered spider monkey, Ateles marguinatus. In the riparian forest, Tapirus terrestris (tapir) and Agouti paca (paca) were the most abundant species, while Cebus apella (capuchin monkey) and Tayassu tajacu (collared peccary) were the most abundant in the terra firme forest. The conservation potential of private forest reserves on large soybean farms and cattle ranches is very large.

9.4: Can LBA science foster the conservation of natural resources through the adoption and certification of "best" agricultural practices?

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One of the most important potential contributions of LBA science to the elusive goal of sustainable development is data, conceptual advances, and methods for monitoring and refining agricultural and ranching practices that conserve natural resources on private properties. Currently, farmers and cattle ranchers are largely on their own in their attempts to improve the environmental management of their properties; those who invest in better management receive little or no recognition by government or civil society, and little technical assistance. The potential benefits to society of widespread adoption of sound environmental management of private properties are not widely disseminated, and little research has been conducted to reduce the costs of environmental management. LBA studies of the carbon dynamics of soil under cultivation and pasture, the biogeochemistry and ecology of small streams that cross agricultural landscapes, the causes and consequences of accidental forest fires, and the modeling/mapping of economic returns to competing land uses all could potentially promote conservation of natural resources on private properties. These studies provide an essential scientific foundation for the recently-launched, civil society initiative that is developing a national (Brazilian) system for the environmental and social certification of large-scale farms and cattle ranches that could ultimately provide positive market incentives for property-holders to improve the environmental management of their properties.

9.5: Investigating Future Trends in Amazon Basin Discharge and Floodplain Inundation

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Population and development pressures in the Amazon Basin have resulted in about 15% of the total land area being deforested as of 2000. The high rates of Amazonian deforestation will continue well into the future, with deforestation scenarios suggesting that 30-50% of the entire Amazon Basin could be deforested by 2050. Impacts on riverine ecosystems goods and services may occur as a result of a large increase in the total discharge and flood extent, as already observed in the Tocantins basin of the eastern Amazon. We have recently used numerical models to investigate the sensitivity of the Amazon River system to scenarios representing deforestation for the period 2000 to 2050. Two different trajectories of deforestation are investigated: 1) Business as Usual (BAU); and 2) Governance (GOV) under which land cover changes are limited by applied governance rules. In our simulations, deforestation, primarily on the main southern tributaries, increases discharge by 10-15% during the wet season in the GOV simulation with 20-30% of the individual basins deforested. With BAU, the discharge during the wet season increases by 20-25% compared to the modern simulation. Similarly, the flooded area of the basin increases with increasing deforestation; for the southern tributaries, the total flooded area during the wet season increases by 15%with GOV and 30%with BAU. The simulated changes in hydrology are consistent with those observed in the Tocantins River basin and indicate that differences in the trajectories of deforestation may significantly influence the future hydrology of the Amazon River.

9.6: The Future Climate of Amazonia

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The climate of Amazonia is responding to two concurrent perturbations: rapid rates of land-use change, mostly conversion of forest to pasture or cropland, and global warming. The former is liked to increased surface temperatures, decreased

evapotranspiratin as revealed by observations. It is being hypothesized the biomass burning may lead to a delay in the onset of the rainy season. Modeling studies indicate that basin-wide rainfall would decrease with large-scale deforestation. On the other hand, various scenarios of regional climate change in Amazonia due to global warming point out to a climate warmer by 2° to 5°C by the end of this century. When these scenarios are used as input to CPTEC Potential Biome Model, it projects that large portions of the forest could become impoverished savannas. Scenarios of biome change and redistribution due to climate must be taken into account for conservation policies of the Amazonian countries.

3C: Terrestrial Carbon Fluxes (2)

10.1: Calibration of IBIS against data from four primary forest sites in Amazonia

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Land surface/ecosystem models, like IBIS, simulate the fluxes of energy, water and CO2 between the surface and the atmosphere. Traditionally in the field, these models are usually calibrated against data collected in one single site per ecosystem. Given the availability of LBA data for Amazonia, in this study, however, we calibrate IBIS against data from four primary rainforest sites in Amazonia (Flona Tapajos km67, Flona Tapajos km83, Reserva do Cuieiras km34 and Rebio Jaru). The process of calibration aims at minimizing the RMSE for latent and sensible heat fluxes, as well as carbon fluxes. The parameter optimization process obtained two different sets of parameters to represent the four sites. This result either indicates that ecosystem parameters vary spatially, or suggests that other differences among sites may cause the differences in the parameters obtained. Discussion with the tower sites scientists is essential to understand these results.

10.2: Understanding nocturnal mixing in cleared areas: Mechanisms of turbulent exchange during nearly calm conditions.

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In the Amazon, the very stable temperature stratification in cleared areas suppresses nocturnal mixing so much that the commonly used eddy covariance technique fails to provide believable estimates of the surface respiration rates. Substitution of data from nights with insufficient mixing for those with similar surface conditions but stronger winds, often used to overcome this difficulty, is no solution, because the strongly stable case occurs in more than 90% of the cases.

Recently, an alternative approach has been proposed for the analysis of turbulent time series. The multiresolution decomposition is a procedure by which one decomposes the signals on their typical scales, through the determination of the statistical moments on successively smaller portions of the initial series. Multiresolution cospectra has the property of satisfying Reynolds average rules, so that its integration agrees with the eddy covariance flux. The scale dependence, on the other hand, is able to identify the nature of the flux, whether it is caused by turbulent or mesoscale motions. Multiresolution cospectra indicate that turbulent fluxes in very stable conditions are very small in magnitude, and have a very short time scale, but are well behaved, differently than the eddy covariance suggests.
In this study, the multiresolution decomposition is applied to the turbulent dataset collected at the LBA-ECO pasture/agricultural site at the km 77 of the Flona Tapajós. Strong nonstationarity proves to be an extra difficulty, causing the turbulent and mesoscale fluxes to overlap in scale. Nocturnal surface fluxes are estimated through this technique, and compared to those computed by the eddy covariance technique and by surface layer accumulation methods. Finally, the fluxes are compared to vertical gradients, on a similarity theory framework.

10.3: Assessing the influence of observational data error on SiB2 model parameter uncertainty

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We used an ensemble approach within the strong constraint data assimilation framework (i.e. assuming a perfect model) to study the effect of (input and output) data uncertainty on the multi-objective parameter estimation problem. To achieve this we used the MOSCEM algorithm and applied it to the SiB2 model and data from the km 83 Santarem tower. The MOSCEM algorithm, which is based on the Markov chain search, provided an estimate of the underlying parameter uncertainty and its distribution. We coupled the optimization algorithm with an ensemble of perturbed input and output sequences that represent the additional uncertainty due to data error in the form of an uncorrelated heteroscedastic measurement uncertainty which maintains the mean, variance, and other statistical properties of the original observational series. The procedure was applied to the latent heat, sensible heat, and carbon fluxes simultaneously, and we identified a collection of 50,000 'optimal' (in the multi-objective sense) parameter sets and, correspondingly, 50,000 objective function points from around one million model simulations. That allows us to establish several regions of attraction, the uncertainty distribution of the parameter sets, and a collection of parameter sets associated with a prescribed level of uncertainty in the observational data.

10.4: Drought effects on seasonal patterns of transpiration in tropical trees.

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Daniel Curtis Nepstad, WHRC/IPAM, dnepstad@whrc.org

Besides global warning, the land use change must provoke changes on water availability. And the features related to regulation of water utilization by tropical tree species and water balance are key components of adaptation to the environment. Our goal is to evaluate the drought effect over the seasonality of stand transpiration. Over the past 6 years we have been monitoring changes in whole-tree water use in 27 tree individuals per plot, plant available soil water (PAW) and leaf area index (LAI) in the rainfall exclusion experiment (Santarem, Para, Brazil). The study consists of two 1-ha plots, a control and treatment plot from which rainfall wet season (6-mos) water inputs have been reduced by 50% since 2000. Transpiration was estimated on the basis of sap-flow measuring (Granier-type sensors) and tree fluxes were scaled to stand level using the circumference quotients. The daily treatment plot transpiration was correlated with LAI and PAW (p^{-1} and 2.96 mm day^{-1} for treatment and control plot, respectively. Treatment plot released 70% less water to the atmosphere in this season. The match of LAI and transpiration is remarkable because of the related importance of canopy integrity to maintenance of transpiration patterns.

10.5: Climatic variance and vulnerability to drought in Amazônia

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Models predict close coupling between increases in aridity under climate-change scenarios and changes in the structure and function of Amazonian forests. Here we empirically assess the climate sensitivity of Amazon vegetation using data for of past climate and current vegetation distribution, with a model for evapotranspiration based on eddy-flux data.We find that drought frequency statistics closely match the forest-savanna distributions and predict areas of the Amazon particularly vulnerable to vegetation change. Our results show that, if these projections were realized, Amazonian equatorial forests would be bisected and fragmented.

Posters

CD (Carbon Dynamics)

11.1-P: Gaps in the forest: how enhanced turbulence affects microclimate and carbon exchange at one study site.

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This study aims to determine how turbulent exchanges in a forest gap determine microclimate and forest-atmosphere mass exchanges. A micrometeorological tower has been operating inside a gap since 2003 at the at LBA km83 FLONA Tapajós site. We present the observations of radiative fluxes, temperature, winds and fluxes in this tower. Emphasis is given to the effect of the gap on surface microclimate. Mechanisms that may locally enhance water vapor and other scalar fluxes are identified. Certain observed features can be understood through reference to large-eddy simulations. These studies aim to determine to what extent gaps are able to anchor the fluxes of a given scalar to a particular location and how much the presence of a nearby gap may affect observations made at flux observation towers. Two different conditions are simulated. In the first, a vortex forms, as the flow finds the reduced drag, related to the gap. In this case, the roll prevents most of the surface-emitted scalars from being transported out of the canopy. The second possible condition does not show the vortex and, in this case, enhanced fluxes are observed above the gap, with surface scalar concentrations enhanced at its surface.

11.2-P: Topography Drives Meso-Scale Heterogeneity of Edaphic and Canopy Properties in Eastern Amazonia.

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Here we have investigated how topography is related to soil texture and leaf area index (LAI) in thirty 0.25ha plots along a ~150 km transect in the Tapajós. We used the Shuttle Radar Topography Mission data to evaluate terrain elevation and slope in this region. A fieldwork was carried out in October 2002. Soil samples were collected (0-10 cm) in three random points in each plot. LAI was measured at 25 points in each plot using the LAI-2000 instrument. The results indicated at least 5 clusters of plots related to the topography. The regions could be identified as Plateau (elevations >190m, slope <2^o); Valley (elevations ~148m, slope 1^o-3^o); Lower-slope (elevations 100-130m) and Upper-slope (elevations 170-190m), both with variable slope (2^o-10^o), and riparian (elevations ~80m, slope 1.4^o-5^o). The slope was negatively related to the clay content (r^2=0.73). This analysis did not consider the Valley samples that follow an independent pattern (low slope and clay content). Clay content varied from 5 to 88%. LAI showed to be a logarithmic function of slope (r^2=0.61), excluding plots located in the Valley regions. Moreover, LAI showed a linear and positive relationship with soil clay content (r^2=0.52). Therefore, we concluded that topography controls the patterns of soil texture and the combination of these two variables establish LAI heterogeneity over the Tapajós. The understanding of the causes of this variability is crucial for increasing the power of the predictions about the function of the Amazonian biome facing to the actual and future climate scenarios.

11.3-P: Vertical structure of the lower atmosphere above cleared and forested areas: implications for understanding carbon exchange

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We report on three campaigns to measure the structure of the nocturnal boundary layer in cleared and forested areas near Santarém PA in 2001 and 2003.
The aim was to describe the temporal evolution of wind and thermodynamic profiles in the stable surface layer and to use the accumulation of scalars, such as CO2 in the layer as a way to infer surface fluxes. This was deemed necessary because the frequent very calm conditions limited the validity of eddy covariance flux CO2 measurements at these sites at night. In 2001, tethered balloon observations were made at a pasture site. In 2003, this study was repeated, with a special balloon sonde deployed to measure CO2, temperature, humidity, and pressure. During the convective period just after sunrise, both the eddy covariance and accumulation flux estimation methods are valid and were compared. At night the key is to determine the thickness of the atmospheric layer to which nocturnal respiratory CO2 accumulates.
In the forest at night the CO2 accumulation layer was basically constant and had a height of 32m. The mean CO2 night flux (Fc) was estimated as 0.07(□0.02)mgCO2/m2s. The average CO2 accumulation rate decreased linearly with height from (12ppm/h) near the ground to less then (1ppm/h) above 30m high. These results are in agreement with the average profiles measured from

forest flux towers. Over plowed field we found a larger CO2 accumulation layer at 60-80m, reaching more then 100m on some nights. The mean CO2 night flux was estimated Fc=0.32(□0.2)mgCO2/m2s. We found a constant CO2 accumulation rate (15ppm/h) from the surface to 30-50m high, and above 50m the accumulation decreased approximately linearly to zero at about 100m.
In this study, these results are presented and compared with the 2001 results as well as with observations from the three LBA-ECO flux towers.

11.4-P: The effect of biomass burning aerosol radiative forcing on the CO2 flux for the LBA Santarem tower

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Biomass burning aerosols strongly affects the radiative forcing in Amazonia during the dry season for large areas. In this study, the effect of biomass burning aerosols and the clouds coverage have been studied along with the CO2 flux (NEE) and meteorological variables in Belterra (Santarém, Pará). For this purpose a dynamical model for optical properties of biomass burning aerosols was used coupled with a radiative transfer model. The CO2 flux (measured using eddy correlation techniques), photosynthetically active radiation (PAR by quantum sensor LI-COR) and optical thickness of aerosols (AOT measured with AERONET sun photometers) were measured. A significant increasing of NEE as a function of the increasing of the AOT during the dry season was observed, up to a certain level. This is a result of the increase in diffuse radiation, despite the reduction in the direct flux. Comparison between Santarem and Rondonia measurements will be done.

11.5-P: The radiative effects of smoke aerosols in the carbon fluxes in the Amazonia

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The interaction of the biomass burning aerosols with the solar radiation affects the atmospheric radiative budget in the surface and changes the fraction between the direct and diffuse radiation of the solar radiation. The high cloud coverage in the region is also another important factor in the radiative budget in the surface. In this work, we study the effects in the radiative budget caused by emissions of biomass burning aerosols and clouds in the CO2 flux (net ecosystem exchange-NEE). A variable named relative irradiance was calculated to express the amount of total solar irradiance that is being extinct due to the atmospheric aerosol loading and clouds in the region. A combined approach involving a radiative transfer model with solar radiation measurements was developed. Aerosol optical thickness (AOT) measurements were made with AERONET CIMEL sun photometers, and CO2 fluxes measurements were determined by eddy-correlation techniques. A forest area, (Reserva Biológica Jarú), and a pasture area, (Fazenda Nossa Senhora Aparecida) were the sites studied, both in Rondônia. In the forest area, it was observed that the NEE increases up to 50 % when the aerosol optical thickness varies from background values of 0.1 to high aerosol loadings of 1.2. This increase in the NEE is attributed to the increase of the diffuse radiation relative to the direct solar radiation. For larger reduction in incident solar radiation, NEE starts to be reduced until reaching values next to zero. The pasture area did not show statistically significant increase in CO2 flux measurements when AOT varies between 0.1 and 1.2. An important influence by cloud coverage was observed in the radiative budget and the NEE measurements. As the large amounts of aerosol particles are transported for long distances, the alteration of the carbon fluxes can be occurring in large areas of Amazonia.

11.6-P: Dinamica do CO2 da respiração do solo, em áreas de floresta nativas da Amazônia

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O sistema climático global e o ciclo do carbono interagem intensamente, e o CO2 constitui um fator dominante na definição do clima, gerado e consumido pela atividade de microrganismos em ecossistemas aquáticos, terrestres e na atmosfera, esse gás contribui para o efeito estufa. Fluxos de CO2 na interface solo-atmosfera dependem de mudanças das características físicas, químicas e biológicas na superfície do solo em um ecossistema de floresta tropical, grande parte da produção de CO2 é proveniente da respiração do solo. O objetivo desse estudo é investigar a variabilidade sazonal dos os fluxo de CO2 decorrente da respiração do solo de florestas nativas da Amazônia, localizadas nos municípios de Santarém (PA), Sinop (MT), Manaus (AM), Caxiuanã (Pa) e determinar os principais parâmetros de correlação do fluxo. Neste Estudo serão feitas correlações isotópicas com fluxo de CO2 do solo- atmosfera. As coletas dos dados foram realizadas nos períodos úmido e seco, no período de um ano. Os fluxos de CO2 foram medidos por meio de câmaras dinâmicas, que se baseiam na variação da concentração do gás no interior da câmara em função do tempo, é calculado através de equações de regressão linear. Os valores médios encontrados para região de Sinop nas estações seca e úmida foram de 3,03 mol CO2 m-2 s-1 e 5,92 mol.CO2m-2s-1 respectivamente;Manaus 5,47 mol. CO2 m-2 s-1 e 5,44 mol CO2m-2 s-1; Santarém 5,64 µmol CO2 m-2 s-1 estação úmida e durante a estação seca de 2,95 µmol CO2 m-2 s-1 e Caxiuanã 5,07 µmol CO2 m-2 s-1 estação seca e 6,09 µmol CO2 m-2 s-1 período úmido. Nossos resultados mostraram

que há variação sazonal no fluxo de CO2 do solo. A quantidade de água e a temperatura do solo foram os principais condicionadores da produção do gás.

11.7-P: Wood and Soil Surface CO_2 Fluxes from the Tapajós National Forest

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Carbon cycling in tropical rainforests is an important component of the global carbon budget. A better understanding of controlling mechanisms and magnitude of CO_2 sources from tropical forests will improve our ability to predict future impacts of climate changes. This research study has focused on determining the magnitude and characteristics of the CO_2 flux from tropical wood and soil surfaces. Stem and soil CO_2 fluxes were measured from a tropical moist forest at Tapajós National Forest in Brazil using infrared gas analysis and chambers. Annual stem CO_2 fluxes averaged 1.7 umol m^{-2} s^{-1}. Wood surface area was calculated (4161 m^2 ha^{-1}) and wood CO_2 flux extrapolated to ground area resulting in an annual flux of 259 g C m^{-2} yr^{-1}. Line sampling of soil-atmosphere CO2 fluxes made on randomly placed 30 m transects averaged 4.7 +/- 0.2 umol m^{-2} s^{-1}. Average soil CO_2 flux during the wet season was higher (4.9 +/- 0.3 umol m^{-2} s^{-1}) than during the dry season (4.4 +/- 0.2 umol m^{-2} s^{-1}). Geostatistical analysis of grid sampling of soil CO_2 fluxes indicated that they were not spatially dependent down to 15 m separation distance. The estimated annual average of soil surface CO_2 flux for the TNF was 1780 g C m^{-2} yr^{-1}. The estimated contribution of wood and roots to gross primary productivity at the TNF are 8.7% and 15%, respectively.

11.8-P: Estimates of Forest Canopy Height and Aboveground Biomass for the Amazon Basin using ICESAT

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Lidar remote sensing has a unique capability for estimating forest canopy height, which has a direct and increasingly well understood relationship to aboveground carbon storage. In our LBA work, we are using lidar waveforms from the Geoscience Laser Altimeter System (GLAS) to estimate canopy height and aboveground forest carbon storage for each GLAS waveform in the Amazon basin and combining those point estimates with images from the MODIS sensor to develop spatially continuous datasets. We will compare the new biomass estimates with spatially explicit data layers from previous studies in the region and use an existing bookkeeping C flux model to evaluate the sensitivity of C flux estimates associated with land cover change in the region to the new biomass estimates.

Despite engineering problems with the GLAS sensor, over 300 million ICESat waveforms have been collected, with nearly 1 million currently available for the Amazon basin. With no other global lidar data collection scheduled for the near future, GLAS data represents a unique source of information on regional-to-global scale forest canopy height and aboveground biomass. GLAS waveforms have an approximate footprint diameter of 70 m and have been generated at 170 m intervals for tracks about 30 km apart at the equator. Processing of GLAS data to create reliable estimates of forest height is complicated by elements of sensor design related to its primary mission—the topographic mapping of the ice sheets of Greenland and Antarctica - and on-going issues associated with instrument performance. Our work to date on the problem has resulted in an algorithm that uses topography from 90 m Shuttle Radar Topography Mission (SRTM) digital elevation models to correct for ground slope effects and create unbiased estimates of stand height. Results from the Tapajos National Forest indicate that GLAS explains 68% of variance in field estimates of forest stand height (RMSE of 9.9 m) and 73% of variance in field estimates of aboveground biomass (RMSE of 58.3 $Mgha^{-1}$). To achieve spatially continuous coverages of biomass, we will employ both multi-phase sampling to create statistical summaries of lidar-estimated attributes over the study region, and statistical data fusion with MODIS data. Comparisons with existing biomass estimates will include surfaces derived from inventory data, interpolations based on climatic gradients and ecosystem carbon models driven by remote sensing data. An evaluation of the sensitivity of the regional carbon flux associated with land cover change to the new biomass estimates will use the Woods Hole Research Center Bookkeeping model. Besides contributing towards the scaling of biomass related field measurements, the mapping the canopy height and biomass of the Amazon has other practical and theoretical justifications, including the testing of various regional carbon models and supplying aerodynamic roughness to climate models.

11.9-P: The Effect of a Canopy Gap on Tropical Forest-Atmosphere Exchange

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Forest canopy gaps potentially provide conduits for preferential venting of subcanopy air, resulting in a spatial redistribution of scalar fluxes. We measured the fluxes of momentum, heat, carbon dioxide, and water vapor along with profiles of carbon dioxide and water vapor from two meteorological towers in a selectively-logged area within Tapajos National Forest. One tower was in a large gap created by logging; the other was 400 m downwind in an intact patch of forest. We found that during daytime the fluxes of carbon dioxide and water vapor were more positive (upward) above the gap than above the intact area. We found evidence that air from the forest understory was the source of carbon dioxide and water vapor vented from the gap. Simple calculations show that the rate of CO2 flux from the gaps could be large.

11.10-P: Avaliação na queda de Liteira em Ecótonos no Entorno da Ilha do Bananal

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A Ilha do Bananal encontram-se no "Arco do Desmatamento" ao longo de um domínio fito-geográfico de transição entre a Floresta úmida e Cerrado. O entendimento dos ecossistemas ecotonais sobre a dinâmica da liteira e trocas de carbono ainda é incipiente. Neste sentido, o presente estudo teve por objetivo avaliar a dinâmica da queda liteira. O estudo foi realizado no Sitio Experimental Javaezinho, localizado entre as coordenadas 9°49´16.1" S e 50° 08´55.3" W, aproximadamente 1½ horas do Centro de Pesquisa Canguçu (CPC) no entorno da Ilha do Bananal - Parque Estadual do Cantão, no período de julho de 2004 a junho de 2005. Para coleta do material foram utilizadas 30 bandejas de 1m2, confeccionados com canos de pvc e tela plástica a 1 m suspenso do solo, dispostas ao longo de um transecto de 200 por 800 m. Em período de cheia, foi necessário o uso de um aparato de câmaras de ar de pneus para elevar o nível das bandejas localizadas em áreas de enchente, permitindo o acompanhamento do nível d'água. O material depositado foi coletado em média a cada 25 dias, separado em frações (folhas, galhos, frutos, flores, sementes e outros), secado em estufa de ventilação forçada a 65 ºC por 72 horas, em seguida pesado. A queda total de biomassa foi de 7,769 ton ha-1 ano-1, com aproximadamente 3,884 toneladas de carbono fixado na biomassa. A deposição das frações de liteira apresentou-se desta forma: Folhas 5123 kg.ha-1ano-1 (65,9%); Galhos 1588,6 kg.ha-1ano-1 (20,4%), Frutos 260,9 kg.ha-1ano-1 (3,4%), Flores 213,8 kg.ha-1ano-1 (2,8%), Sementes 111,8 kg.ha-1ano-1 (1,4%) e Outros (6,1%) com 470,8 kg.ha-1ano-1. O mês de maior contribuição foi o mês de outubro de 2004 com 868,1 kg ha-1, seguido do mês de junho de 2004 com 854,6 Kg ha-1.

Palavras-chave: Serrapilheira, Floresta-Cerrado, Cantão.

11.11-P: Effects of the Surrounding Matrix on Tree Recruitment in Amazonian Forest Fragments

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Little is known about how the surrounding modified matrix affects tree recruitment in fragmented forests. We contrasted effects of two different matrix types, Vismia- and Cecropia-dominated regrowth, on recruitment of pioneer tree species in forest fragments in central Amazonia. Our analyses were based on 22 1-ha plots in seven experimental forest fragments ranging from 1-100 ha in area. By 13 to 17 years after fragmentation, the population density of pioneer trees was significantly higher in plots surrounded by Vismia regrowth than in plots surrounded by Cecropia regrowth, and the species composition and dominance of pioneers differed markedly between the two matrix types. In addition, tree mortality was a strong predictor of changes in florist composition between the initial and final censuses, as revealed by strong, positive relationships between mean tree mortality and changes in ordination scores for both the Vismia and Cecropia plots. Cecropia sciadophylla was the most abundant pioneer in fragments surrounded by Cecropia regrowth (constituting nearly 50% of all pioneer trees), whereas densities of species in Vismia-surrounded fragments were more distributed evenly. Thus, the surrounding matrix had a strong influence on patterns of tree recruitment in Amazonian forest fragments.

11.12-P: Monitoring and modeling the seasonal dynamics of Amazon rainforests

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In Amazonia, interactions among patterns of rainfall, sunlight and soil rooting depth produce complex spatio-temporal dynamics in vegetation. It has been difficult to obtain a synoptic view of these interactions because of a lack of adequate ground observations and unreliable satellite data due to inadequate corrections for clouds and aerosols. Here we used 5 years (2000-2004) of state-of-the art Earth Observing System data from MODIS/MISR/CERES/TRMM sensors along with an ecosystem models to understand the

interactions among leaf area index, sunlight and rooting depth. We used data from MODIS and MISR to estimate leaf area index, CERES for incident shortwave radiation, TRMM for rainfall. The BIOME-BGC ecosystem model was used to optimize rooting depths that produced seasonal patterns of vegetation activity matching the observed patterns of leaf area index and Enhanced Vegetation Index (EVI).

Analysis of monthly TRMM rainfall and MODIS land cover data show that 32% of Amazon forests have dry season length (<200mm/month) of 5months, and 60% have less than 5 months. Over 40% of Amazon forests have annual rainfall amounts of 215cm/year, close to 220cm/yr where previous studies showed rainfall-net primary production curve to peak. Preliminary analyses of both MODIS-LAI and EVI show vegetation to be greening up in the dry season, suggesting that a majority of Amazon forests may be light-limited. This is further confirmed by a positive correlation between monthly variations in LAI and CERES solar radiation and negative correlation between TRMM rainfall and LAI. Model simulations showed that rooting depth settings in BGC, in association with the length of dry season, strongly controlled the temporal dynamics of vegetation activity. Regions with longer dry seasons required rooting depths of 5-8m to reproduce the observed temporal patterns of LAI and EVI.

Our preliminary analyses focused on seasonal dynamics of broadleaf forests in Amazonia. Much remains to be explored in the areas of interannual variability, dynamics of non-forest vegetation, and effects of aerosols on satellite retrievals. We plan to include GOES-based solar radiation and products from SPOT-VEGETATION in future analyses. We hope to create and provide to the community a comprehensive mutli-sensor data set of Amazonia.

11.13-P: Examination of Tropical Forest Canopy Profiles Using Field Data and Remotely Sensed Imagery

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Structural properties of forests are closely linked with ecosystem functioning. One such forest structural component is canopy depth or canopy profile. Knowledge of canopy profiles is important in understanding gap formation and dynamics, light penetration, and surface roughness; all important parameters in ecological models that are demographic, physiological, or physical in nature. Our analysis compares field based data of canopy profile with estimates derived from remotely sensed images for an undisturbed forest in the Tapajos National Forest, Para, Brazil (3.08 S°, 54.94 W°). We used a handheld laser rangefinder to estimate canopy depth by pointing it directly up in the canopy. We sampled along multiple transects (6 km total) obtaining approximately 20 points every 50 meters. From this data we developed canopy profiles using two distinct methods. Previously, we developed a crown detection algorithm that used high resolution satellite image data. In this work we have further developed the algorithm to examine canopy depth. The algorithm utilized two allometric equations that relate crown width to the top of the canopy and bottom of the canopy. Automated analysis of IKONOS imagery allowed us to also estimate the frequency of crown at various heights. Ability to estimate canopy profiles and forest structural properties in vast areas of the Brazilian Amazon using IKONOS imagery is vital to enhancing our understand of the regional carbon balance.

11.14-P: Produção anual de liteira grossa em floresta explorada seletivamente em MT

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A extração seletiva de madeira aumenta o aporte de detritos vegetais, provocando alterações na produção e decomposição de madeira e, portanto, na dinâmica do carbono nestas florestas. Este trabalho avaliou a produção anual de liteira grossa (? > 2 cm) em parcelas submetidas ao corte florestal com diferentes idades (3, 7-8 e 12-13 anos), no noroeste de Mato Grosso. As maiores produções de liteira grossa foram encontradas nas parcelas com 12-13 anos após o corte (6,7 Mg.ha-1.ano-1) e testemunhas (5,7 Mg.ha-1.ano-1); as parcelas com 7-8 anos (2,8 Mg.ha-1.ano-1) e 3 anos (1,1 Mg.ha-1.ano-1) apresentaram produções muito menores de liteira grossa. A liteira com diâmetro 2-10 cm respondeu por 8% da produção (0,45 Mg.ha-1.ano-1) na área testemunha, 9% (0,59 Mg.ha-1.ano-1) na idade de 12-13 anos, 34% (0,36 Mg.ha-1.ano-1) na idade de 3 anos, e 40% (1,12 Mg.ha-1.ano-1) na idade de 7-8 anos. Na área testemunha, o principal aporte foi proveniente de detritos em estágios iniciais de decomposição. Nas parcelas exploradas seletivamente ocorreu um aumento na produção de liteira em estágios mais avançados de decomposição, que representou 40% da necromassa produzida (na área não-explorada esse material correspondeu a menos de 10% do total). A causa provável é a queda de liteira proveniente de árvores mortas em pé e danificadas pela exploração florestal. Outro fator com forte influência neste aumento foi que as parcelas com idade de 3 anos foram submetidas à exploração de impacto reduzido, enquanto que as demais foram submetidas à exploração convencional, com maiores impactos à vegetação, devido à falta de um adequado planejamento.

11.15-P: Monitoring Carbon, Heat, and Water Vapor turbulent fluxes over an Agricultural Field in Santarém II.

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We present results from a micrometeorological point of view of the land-use change in Santarém, PA. Since the 1970's the Amazonian deforestation resulted from forest to pasture conversion. However, in recent years, there has been an increase of the area of rice and soybean plantation in the Santarém region. In the Large scale Biosphere-Atmosphere experiment in Amazonia (LBA) there is a continuing effort to understand the consequences of this land use conversion by exploring a continuous data set. This study presents the results of turbulent flux measurements of carbon, heat, and moisture using an eddy covariance flux observation system located in an agricultural site in the Eastern Amazon. During the last 6 years this field has been transformed from a pasture to a rice and soybean plantation. We will show the changes in turbulent fluxes (CO2, H20, and heat), radiative parameters (albedo and PAR-albedo) due to changing landscape from a pasture to crop fields. We also will show the impact of burning and plowing techniques on these parameters.

11.16-P: Distribuição Espacial de Carbono em Solo Sob Floresta Primária na Amazônia Meridional

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O estudo do carbono assume grande importância devido à sua estreita relação com as mudanças climáticas da terra. Uma das causas relevantes dessas alterações é a rápida substituição das florestas tropicais da Amazônia por sistemas agropecuários, sem o devido fundamento científico. Este trabalho foi desenvolvido em Juruena (MT), com os seguintes objetivos: estudo da distribuição espacial do teor de carbono e a estimativa do seu estoque na camada de 0-60 cm de solo sob floresta primária, por meio de técnicas geoestatísticas. Foram demarcados 185 pontos georreferenciados em forma de malha sistemática regular, com espaçamento de 20x20 m, onde foram coletadas amostras de solo com trado holandês nas profundidades de 0-20 cm, 20-40 cm e 40-60 cm. Para a determinação da densidade aparente até a profundidade de 0-60 cm, foram retiradas amostras com estrutura não deformada por meio de anéis de aço de Kopecky. A densidade aparente aumentou de 1,36±0,081 g.cm-3 (± desvio padrão) para 1,46±0,083 g.cm-3, nas profundidades de 0-20 cm e 40-60 cm, respectivamente. As microbacias apresentaram estoques médios de carbono (profundidade de 0-60 cm) distribuídos da seguinte forma: microbacia 1 = 56,73 t.ha-1, microbacia 2 = 59,35 t.ha-1, microbacia 3 = 59,22 t.ha-1 e microbacia 4 = 64,35 t.ha-1; com média geral de 59,74±10,30 t.ha-1.

Palavras-chave: geoestatística, krigagem e dependência espacial.

11.17-P: Assessing the importance of subcanopy drainage on net carbon exchange at the FLONA Tapajós

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There is increasing concern in the scientific community about how well eddy covariance (EC) flux measurements over forests with complex terrain can describe the complete carbon exchange. Recently, some studies have indicated that horizontal advection, generated by understory flows, could explain the fact that eddy covariance observations do not capture flux on calm nights. There is still insufficient understanding of the nature of horizontal subcanopy advection, primarily due to the lack of detailed field data in different biome types. Because this question has not yet been addressed in a tropical forest, we measured understory wind field and horizontal CO2 gradients at the Flona Tapajos Old Growth Site between July 2003 and December 2004. The aim is to assess the importance and the contribution of the mean advection terms to the transport and budget of CO2. The two periods selected for analysis were July to August 2003 and October 2004 to January 2005. Measurements of CO2 concentration taken by our group and others at the same site are very consistent. The results indicate that at night, the understory wind field is persistently East-Southeast, which oftentimes is decoupled from the air above the canopy, but correlates with the Jamaraqua weather station measurements and may be influenced by the Tapajos river breeze. As expected, for mildly inclined topography, the horizontal advective terms presented small values, but are still important in accounting for the CO2 budget. The persistent subcanopy wind field direction leads to the conclusion that the advection was primarily generated by topography.

HY (Hydrometeorology)

12.1-P: Modeling the Effects of Throughfall Reduction on Soil Water Content

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Access to water reserves in deep soil during drought periods determines whether or not the tropical moist forests of Amazonia will be buffered from the deleterious effects of water deficits. Changing climatic conditions are predicted to increase periods of drought in Amazonian forests and may lead to increased tree mortality, changes in forest composition, or greater susceptibility to fire. A throughfall reduction experiment has been established in the Tapajós National Forest of east-central Amazonia (Brazil) to test the potential effects of severe water stress during prolonged droughts. Using Time-Domain Reflectometry observations of water contents from this experiment we have developed a dynamic, one-dimensional, vertical flow model to elucidate our understanding of hydrologic processes within these tall-stature forests on well-drained, upland, deep Oxisols and to simulate changes in the distribution of soil water. Simulations using 960 days of data accurately captured mild soil-water depletion near the surface after the first treatment year and decreasing soil moisture at depth during the second treatment year. The model is sensitive to the water retention and unsaturated flow equation parameters, specifically the van Genuchten parameters θ_s, θ_r, and n, but less sensitive to K_s and α. The low root-mean-square-error between observed and predicted volumetric soil water content suggests that this vertical flow model captures the most important hydrologic processes in the upper-landscape position of this study site. The model indicates that rates of evapotranspiration within the exclusion plot have been sustained at the expense of soil water storage.

12.2-P: Mesoclimate at the Tapajós-Amazon confluence

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The relatively few surface climate stations in the Amazon play an important role in defining the meaning of remotely sensed data and in constraining large-scale models. We identify the consequences of local circulations on winds, the average incident solar radiation, surface temperature and humidity, and rainfall using data from eight automatic weather stations and three flux towers located in the LBA-ECO Santarém study area. Results include:
* Nocturnal average wind speeds at 3 m altitude near the Amazon River are comparable to those observed at the top of the 63 m tower at the km83 site;
* The diurnal distribution of rainfall amount indicates that stations close to the river fail to observe afternoon convective rainfall correctly. Stations near the river register only the 'basin-wide' precipitation resulting from synoptic disturbances that typically pass through this region in the very early morning. This may explain difficulties in comparing observed rainfall with inferred rainfall from outgoing longwave radiation (OLR) in this region.
* Breeze effects are present on most days; flow reversal only occurs during period of slack easterlies.
* Statistics of global incident short-wave radiation were used to determine and correct for sensor degradation with time. Average maximum hourly solar radiation peaks are coincident with local noon, but the effects of clouds push the average hourly radiative flux to later in the day. The average hourly minimum solar radiation peaks before (after) local noon for sites near (distant from) the river.

12.3-P: Projected Amazonian Deforestation in the 21th Century and Possible Regional Climatic Impacts

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In the last years, many authors have discussed the possible effects of tropical deforestation on global climate processes. Many AGCM modeling studies have considered the sensitivity of the climate system to a complete conversion of Amazonian rainforests to pastures (Dickinson and Henderson-Sellers, 1988; Nobre et al., 1991, Henderson-Sellers et al., 1993). Most of these studies have showed the importance of the tropical rainforests for the Earth's climate. The climate of Amazonia is responding to two concurrent pertubations: rapid rates of land-use change, mostly conversion of forest to pasture or cropland, and global warming. The present work evaluates the impacts of the conversion of Amazonia rainforest to pasture, using four distinct scenarios: 1) land cover scenario for year 2025 (~28% deforested area - from Soares-Filho- Amazon Scenarios Project, 2005); 2) scenario for year 2050; 3) scenario for year 2075; and 4) scenario for year 2100 (~67% deforested area). In all cases, the deforested areas are replaced by degraded grass (pasture). We have used CPTEC global atmospheric model to assess the effects of Amazonian deforestation on the regional climate. The results shows increase in surface temperature, a decrease in evapotranspiration and precipitation. There is also a discussion on changes of precipitation patterns.

12.4-P: The impact of the ongoing deforestation on the hydrological cycle: a case study of the Cuiabá-Santarém highway

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This study aim was to evaluate some impacts on the hydrological cycle, specially the precipitation pattern, due to the regional

deforestation along the corridor of the Cuiaba-Santarem highway (BR-163), using a high resolution atmospheric model, the Regional Atmospheric Modeling System (RAMS), in its Brazilian version, the Brazilian RAMS or BRAMS. A deforestation scenario for 2026 has been provided by empirical models of deforestation, under no governance conditions (also known as the business-as-usual scenario) and it has been used in this study. The time length of simulation was 40 days, from October 10th to November 30th. The forcing data of 2002 were provided by the NCEP/NCAR Reanalysis Project. Mean rainfall decreased 7% in the region in which the forest was replaced by pasture. There were no substantial changes where the forest land cover was kept undisturbed. However, the rainfall showed spatial variability due to the local circulation (thermal) induced by land cover heterogeneity. Over the pasture area (deforestation), hot air rises by convergence carrying water vapour from the undisturbed forest located close to the pasture increasing the convective precipitation. This local cell is approximately twice as big as the deforestation length. In the BR-163 study case, the cell was located nearest to the west side of the land cover transition area (forest-pasture) where the rainfall rate increased. On the east side and over the deforestation area, the precipitation rate was reduced. The diurnal cycle of the precipitation has been slightly changed in the deforestation case. During the day, it was not possible to identify the rainfall maximum while at night it suggested a slightly increase of precipitation. The response of the fluxes and surface variables may be different depending on its topography level. A small rainfall reduction has been observed where the forest was kept undisturbed over 500 meters.

LC (Land Use and Land Cover Change)

13.1-P: Modeling Beef Yields in the Brazilian Amazon

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Most of the work undertaken in the Brazilian Amazon has focused on assessing the interplay between livestock expansion and deforestation, because its implications on economic growth and its environmental impacts on global climate change. Livestock expansion, however, does not follow an homogeneous pattern across space due to the fact it depends largely on varying degrees of the livestock production's intensification. In turn, disparate beef productivity may impact differently on pasture use, and hence on land occupation dynamics. Most of the modeling effort to understand livestock sector growth have often been spent in their linkages with land-use/cover change. This work was more concerned with elucidating the factors, both economic and biophysical, that influence on livestock yields, mainly of beef production in the Brazilian Amazon. To do that a multivariate linear OLS regression is employed for simulation. The unit of analysis is the census tract. Data provided for the IBGE, Agricultural Census 1995-1996 consist of average values for each census tract. Different models were performed with a pooled cross-sectional data at the census tract level, comprising the whole of the Brazilian Amazon region, using the statistical software SPSS. Different variables were tested but only some became statistically significant.
The model predicts livestock yield in the Brazilian Amazon, particularly for beef production, which indirectly explains the main determinants for beef production intensification in this region. The model provided integrates data representing the economic performance of cattle ranches in the Amazon, and physical data to depict the main spatial factors linked to beef production such as transportation costs, topography, and precipitation. Livestock dynamics in the Amazon are highly variable across space, as well it is beef production. The model accounted for such spatial variability, and offered a robust set of parameters to predict beef productivity.

13.2-P: Avaliação de Mapas Temáticos CBERS em Sítios do LBA nas Proximidades de Santarém/Amazônia Legal

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A representação dos cenários terrestres com uma boa acurácia é de vital importância para modelos de superfície(Sellers et al. 1986). A representação inadequada ou insuficiente das condições e dos processos da superfície terrestre podem ter um impacto negativo sobre os modelos de Previsão de tempo e clima(Xue et al. 1996). Em um esforço conjunto, Brasil e China têm desenvolvimento a série de satélites CBERS. A bordo destes satélites encontram-se três tipos de instrumentos: CCD, IRMSS e WFI. Durante a aquisição alguns tipos de degradação podem ocorrer nas imagens, contaminando as informações nela contidas. Este estudo tem como objetivo apresentar as imagens CBERS como uma alternativa para a caracterização da cobertura vegetal na Amazônia Lega, avaliando a acurácia desta caracterização. Serão apresentados mapas temáticos através de técnicas de classificação supervisionada, para a análise quantitativa das imagens adquiridas pelo sensor CCD (resolução espacial, 20m). Para isto utiliza-se duas tabelas de classes, uma gerada com base na tabela de vegetação existente no modelo BRAMS e outra a partir das classes realmente existentes na imagem. As áreas para a verificação da verdade terrestre estão localizadas em sitios experimentaisdo projeto LBA, nas proximidades de Santarém-PA. Com a uso de classificadores e "imagens de distância", serão identificadas áreas não classificadas, ou classificadas incorretamente, apontando-se áreas de tensão ecológica onde coexistem duas ou mais classes de cobertura vegetal(Sestini et al.2003), bem como classes para uma possível inclusão em tabelas de vegetação, como a existente no modelo BRAMS e outros modelos atmosféricos. Para a verificação da acurácia dos classificadores e quantificar o grau de separabilidade das classes, serão utilizadas técnicas como Maximum Likelihood, imagens de distância de Mahalanobis e Distância de Jeffries-Matusita(Richards, 1999).

13.3-P: Temporal pattern of deforestation over the Mato Grosso State

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The Moderate resolution satellite data EO-1 Terra and Aqua MODIS sensors, permit a rapid analysis of deforestation in the Brazilian Amazon, and it is being developed by INPE's DETER project (Real Time Deforestation Detection in Amazonia). Based on a high temporal deforestation detection data, it is now possible to explore not only the shape and the size of the deforestations, but also the temporal pattern of its occurrence. This work reports the preliminary results of the evaluation of monthly DETER data for the Mato Grosso State. The study area was selected based on PRODES data for 2002 and 2004, that it presented the highest deforestation rate in the Brazilian Legal Amazon. Our hypothesis was that is possible to detect the diversity of a temporal pattern for the deforestation process. With an one year DETER data series, we evaluate when the deforestation processes is more critical, what is the priority for the INPE PRODES program based in these new pattern for this region and the integrity of the Conservation Units System (CUS) and indigenous lands (ILs) over the forest region. Our preliminary results showed a presence of the deforestation activities during the whole period studied, even during the wet season. The critical months for 2004 year were May and June, while for 2005 was April and May. The most part of the new deforested areas were in the axis of the main road (Cuiabá-Santarém), and in Xingú Indigenous Reserve's outside limits. It was also observed new deforestation in the north-west limits of the State. The CUS and ILs showed to be an important barrier for the deforestation process, even with all the pressure of land cover change close to its limits.

13.4-P: Scenarios for econometrics projections: The future of the Amazon

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Projecting future of Amazon land cover in the interesting of understands its sustainability properties; require both modeling and the developing of likely scenarios. Our project entitled A Basic Scale Econometric Model for Projecting Future Amazon Landscape is developing both modeling approach and scenarios upon which scenarios would be base. This poster presents elements of the scenarios that will be used in our efforts to understand the future of Amazon. We present here in this poster these scenarios along three dimensions, (1) demographic trends; (2) infrastructure developments, and (3) protected areas and zoning regulations. For demographic trends, the poster presents regional population projections, for both rural and urban areas, under various assumptions about fertility, mortality, and migration. It applies standard demographic techniques, and discusses magnitudes of change relative to current levels. Regarding infrastructure development, the poster pays special attention to Avança Brasil. Specifically, we present (1) the plan in it full detail as first proposed by President Cardoso, and (2) the plan as it is likely to be implemented in the short to mid-run, given priorities of the current administration. As for protected areas and zoning regulations, we present graphics showing the current scheme of protected areas, including conversation and preservation units of various types; we discuss pertinent environmental regulations in this regard. We also present graphic on planned land use zones in Pará, Mato Grosso, and Rondonia. Finally, the poster contains text describing how the scenario information is utilized by econometric modeling to project future landscapes.

13.5-P: Analysis of land cover change in the Capitao Poco, Para region over a 20-year period based on Landsat MSS, TM and the Advanced Line Imager (ALI) data

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We analyzed the common area of five dates of Landsat imagery (P/R 223-61) and one date of Advanced Line Imager (ALI) data from the Capitao Poco, Para. We used MSS imagery from 1984, TM imagery from 1994, 1999, 2001 and 2002 and ALI imagery from 2004. Two challenges of this effort are changes in resolution and numbers of spectral bands from earlier MSS imagery to TM imagery and second, using newer ALI imagery from a different sensing platform.

This region is an area of older colonization where forest clearing has occurred since the opening of the Belem-Brasilia highway in the 1960s. The area analyzed covers 1,800 km2 arranged along a N-S swath chosen to cover a mosaic of 4 strips of ALI data acquired October 14, 2004. The area is unusual in that there remain two large intact forest patches, one 37 km2 and one 9 km2. In 1984 the largest mature forest patch was more than 243 km2.

Over this period, we see a continuing loss of mature forest and a large increase in pasture. From initial analysis using the 1984 MSS data, the region was 33% forest, 39 % secondary forest, and 28% pasture, bare soil and agriculture. Based on the ALI data, in 2004 the region was composed of 26% forest, 30% secondary forest, 43 % pasture, agriculture and bare soil. From 192 GPS points of different landcover types, we will compare the utility of Landsat and ALI data for examining primary forest, different age secondary forests, and other types land cover.

13.6-P: Accuracy assessment, land cover patterns, and capacity-building in the trinational Acre River Basin: pieces of the jigsaw puzzle of sustainable development in Southwestern Amazonia.

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International river basins in Amazonia, such as that of the Acre River - shared by Peru, Brazil, and Bolivia - represent special challenges for integrated management. Such management depends on local capability to exchange information for decision-making. We used SPRING 4.1 freeware to test standard and modified approaches of INPE's PRODES method for estimating deforestation. The standard PRODES approach, applied to the Landsat TM+ image 002/67 10/08/2002, estimated 249.6 km2 /yr of area deforested, within 5% of INPE's published value. To map riparian forests and small clearings, the PRODES method was modified by: 1) eliminating the mask; 2) changing spatial resolution to 30 m; and 3) decreasing the minimum mapped area to 0.36 ha. The modified PRODES approach produced 14% less area deforested than the standard approach. In comparison with a QuickBird scene, the omission/comission errors of the modified PRODES approach for area deforested were 6%/1%, respectively. This modified method estimated the area deforested in the trinational portion of the basin: 13% in 2002 (1014 km2), of which 68% was in Brazil. Six sub-basins (25% of total area) contained 58% of the total deforested area. They had 1,340 km of riparian forest ±30 m along streams (streams defined by a minimum area of drainage ~80 ha from SRTM data) of which 477 km (33%) was already deforested. The ratio of deforested riparian forest to area deforested was 0.8 km/km2. If this ratio is representative, then Acre State has 104 km of deforested riparian forests. Over 100 persons in the three countries were introduced to SPRING freeware to facilitate use of the datasets generated in this study for management of the Acre River Basin.

13.7-P: Scaling the structural attributes of Amazonian secondary forest from the stand level to a regional scale

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The Amazonian rainforest of South America is undergoing large-scale human induced change. The mosaic of land cover types created by the pattern of land clearing for agriculture, subsequent abandonment, and vegetation regrowth is expanding further into the neotropical rainforest. Many studies conducted over the last decade have demonstrated that regrowing forests play an important role in the Amazonian carbon cycle (Neeff et al. 2005; Hirsch et al. 2004; Zarin et al. 2001). We present results of our research into the dynamic structural properties of secondary vegetation. In this study, we combine measurements gathered in an intensive field campaign with a 12-year database of satellite-measured reflectances and land cover classifications using a mixture modeling framework. With this modeling framework and rich datasets, we identify potential factors controlling forest structure in regenerating forests. Our results should aid in basin wide estimates of secondary vegetation structure in Amazonia, which are useful in modeling the region's carbon dynamics.

13.8-P: Statistical Analysis on Land Cover Change in Santarém, Pará: A Transition Matrix between 1986- 2001.

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This poster explores the relationship of land cover dynamics in Santarém region for 113 rural properties. The goal is to investigate the correlations between household decision making and land cover changes between 1986 and 2001. The analysis investigates the differences between these two distinct time periods. Using non-linear correlation tests the results indicate the differences in perennial production and pasture are significantly correlated to change in forest cover to non-forest. In addition, testing the changes for secondary succession to a deforested landscape, the results indicate the difference in pasture is significantly correlated.

Linear regression test for the changes of forest to bare soil indicate the differences in pasture and property size has a relationship to deforestation. Additionally, the differences in property size, amount of cattle, and pasture size have a relationship with the conversion of secondary succession to a deforested landscape. These results are indictors that the farmers are not only converting the forested landscape directly to bare soil but also there is a step in-between which is increasing the conversion of secondary succession to bare soil. This poster also suggests that additional land use studies in the Santarém region, Pará are necessary to

examine possible environmental changes and the drivers that affect land use decision making. This poster is based from ethnographic and survey-based fieldwork carried out by a team of researchers at the Anthropological Center for Training and Research on Global Environmental Change (ACT) at Indiana University as a part of a larger project on human-environment interactions in the Brazilian Amazon supported by NASA LBA-Eco grant, a NIH grant, and IBGE (Instituto Brasileiro de Geografia e Estatistica) data starting from 1970s to the present.

13.9-P: Synthesis Studies of Intensive Agriculture Impacts in the Brazilian Amazon: Field Data, Remote Sensing, and Modeling Approaches (TG-30)

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The expansion of intensive agricultural practices into former Cerrado and seasonal forests of the eastern Amazon has increased markedly over the past several years. Over the last 30 years an estimated 37 percent of Cerrado natural vegetation has been transformed, with more than 12 million hectares planted to crops consisting mostly of soybeans, maize, and rice. We are synthesizing measurement data and MODIS remote sensing observations at locations that represent conversion of Cerrado types and Amazon forests to intensive agricultural land use. A principal objective is to improve calibration of the NASA-CASA model and subsequently evaluate and refine a series of model simulation runs for these transformed ecosystems.

13.10-P: Methodology based on vegetation continuous fields techniques for the integration of medium and moderate spatial resolution satellite data in monitoring the vegetation cover changes in Amazonia

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Currently, numerous efforts to map and monitor the land cover changes in the Brazilian Amazonia have been based on Landsat satellite data analysis, consuming for this, an expressive number of laboratory hours for processing these data. Besides, estimates of different analysis (using smaller spatial resolution data - AVHRR) have been generated conflict results, caused by the differences of definitions and of methodologies applied by several researchers in this study. In this way, this work had as general objective to develop a methodology for monitoring the vegetation cover dynamic in Amazonia, where a larger emphasis will be given in the integration of different sensor data with different spatial resolutions (Terra/MODIS, Landsat/TM and ETM+, and CBERS 2/CCD. As the study area, it was chosen one region in Mato Grosso State, for presenting a great representativity of the Brazilian Amazonia in terms of land cover characteristics. The methodological process elaboration occurred, jointly, with the application of several tests, using different training data (obtained through different applied processes to the ETM+, TM and CBERS/CCD scenes), individually or in group.As result, it was obtained a monitoring system with capability of obtaining data (maps), for 500m and/or 250m of MODIS, in a period that can vary from one month to one year. Through its preliminary results and its comparison with the data obtained from PRODES Project (year of 2002), the feasibility of the presented methodology was verified, providing also a considerable gain in the automation of the methodological process, especially in the processing time (approximately two hours) of its data. It is expected that with this methodology the monitoring of vegetation cover dynamics contribute, especially, to the SIVAM Project, and also, complement projects already developed for the Brazilian Amazonia, as it is the case of PRODES project.

13.11-P: Conservation Units Systems: what environments are being preserved over the Mato Grosso State?

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According to the PRODES data for 2004, the Mato Grosso State presented the highest deforestation rate in the Brazilian Legal Amazon. Immediate environmental conservation plans and actions are urgent, such as the establishment of a Conservation Units System (CUS). In this context, we analyzed the representativeness of CUS and the conservationist role of the indigenous lands (ILs) using maps: potential vegetation, updated land cover, present conservation units (CUs) and indigenous lands. These data were integrated into a GIS, thus obtaining information about the evolution of Mato Grosso's landscape, CUS representativeness and the impact of ILs inclusion in the system representativeness. The results showed that vegetation cover conversions reach 47% of the Cerrado biome, 41% of forest formations and 46% of transition areas, leaving only 66% of the State with natural cover. Additionally the CUS represent only 2.4% of the State and not including all vegetation formations. The lack of policing in the CUs aggravates the problem, since we detected conversion proportions of more than 50% for some vegetation formations inside protected areas. With the inclusion of ILs, the area of the protected areas increased to 16% of the State. The proportional of

natural cover conversion (9%) inside the ILs was lower than for the CUs (21%), but even these areas offering more representativeness and protection than the CUs, the ILs do not ensure the conservation/protection of the ecosystems, as long as this picture tend to change with the progressive "civilization" of its people. In order to the CUS become efficient, we suggest the system's enlargement by the creation of CUs (considering the representativeness/protection criteria) and inclusion of the Is. However, such actions will only be truly valid if followed by effective policy rules on the CUS.

13.12-P: The use of SRTM elevation data for forest/land use zoning by ethnic communities: the example of the Kampa Indigenous Land of the Amonia River along the Acre-Brazil/Ucayali-Peru frontier

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Indigenous lands occupy 12% of Brazil and are not considered conservation units. While they are an essential instrument for protection of indigenous cultures, these lands also conserve natural resources and maintain environmental services. Ethnic zoning of indigenous lands has become an important tool for Indigenous management of these lands. In the case of the Kampa Indigenous Land of the Amonia River (KILAM, 870 km2) in western Acre Sate, Brazil, the lack of a cartographic base at an adequate scale impeded such ethnic zoning. Using digital topographic data derived from SRTM/NASA with IDRISI 32 software, we derived hydrographic drainage networks of 1:80,000. This network, combined with LandSat TM+ imagery of 2002 allowed us to generate land cover and hydrographic maps of the KILAM at 1:50,000 scale. The technical team of the Pro-Indian Commission of Acre (CPI) conducted two capacity-building workshops in the Asheninka community of Apiwtxa on the Amonia River near the frontier of Brazil/Peru. Community representatives used the base maps to generate georeferenced thematic information on vegetation, use of natural resources, incursions of foreigners, presence and migration of fauna, regional history, and fishing. These products have become important tools for the Asheninka community to maintain integrated management of its territory. The use of base maps accelerates the mapping effort and can be replicated in other indigenous lands; it requires, however, mastery of geoprocessing tools for its execution.

13.13-P: Hot pixels and public policy in southwestern Amazonia: the role of accuracy assessment in dissemination of satellite-derived estimates of fire events

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Data on fire occurrence derived from satellites have the potential of providing daily information on land use changes, smoke generation, and fire risks in southwestern Amazonia. For this information to affect societal decisions, accuracy assessment is critical for credibility, particularly as media professionals and governmental officials become more knowledgeable. Helicopter overflights and road observations in 2004 had shown that omission errors for hot pixel detection of fire events were high in eastern Acre State. Inter-comparison of satellites for fire detection in 2005 indicated that fire detection suffers frequently from poor or missing satellite coverage (NOAA and MODIS) that can cause errors of omission on individual days. Consequently, we used hot pixels from multiple satellites (www.cptec.inpe.br/ queimadas), combined with Rapidfire products (http:// rapidfire.sci. gsfc. nasa.gov/ subsets/ ?AERONET_Rio_Branco) to determine patterns of fire events. The public's interest in such information grew in 2005 as an extended dry season created a 34-year low in river levels and made regional forests inflammable. During August and September 2005, in presentations to the Acre State Fire Committee, to Civil Defense representatives of Brazil, Bolivia and Peru, and in radio and TV interviews, we frequently received direct questions as to the reliability of hot pixels as detectors of fire events. These data were then used to help justify a month-long fire moratorium declared by Acre's governor on 18 August. Accuracy assessment of hot pixel data has become a obligatory part of the dissemination process, especially when these data are used for public policy and societal decisions.

13.14-P: Characterizing the Physical Environment of Urban Centers in Rondônia with Landsat ETM+

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Dar A. Roberts, Department of Geography, University of California, Santa Barbara, dar@geog.ucsb.edu (Presenting)

While much effort has been devoted to studying rural land-cover change in Rondônia, very little work has considered the relationship between urban areas and regional land-cover change. A first step in building this connection is to characterize the physical environment of urban centers and their immediate surroundings. The urban physical environment is composed of three

primary components—vegetation, impervious surfaces, and soil (V-I-S components), in addition to water. Ten urban centers in Rondônia were selected for analysis, representing a range of populations, development histories, and economic activities. For each urban sample, a 20x20-km region centered over the built-up area was subset from 1999 or 2000 Landsat ETM+ imagery. Multiple endmember spectral mixture analysis (MESMA) was applied to each image subset, and the sub-pixel abundance of V-I-S components was mapped. Accuracy of the modeled V-I-S fractions was assessed using high-resolution images mosaicked from digital aerial videography. Several potentially significant findings emerge from this analysis. First, modeled fractions and reference fractions were highly correlated, demonstrating the potential of moderate-resolution imagery to map the physical urban environment. Second, model complexity—how many endmembers are required to accurately model each pixel—was related to the degree of human impact on the landscape, with highly impacted areas requiring more complex models. This relationship was used to delineate the built-up extent of settlements, suggesting the possibility of automated mapping of urban extent. Finally, V-I-S components captured inter- and intra-urban variability, suggesting that these data products can contribute to comparative studies of urbanizing areas.

13.15-P: Germinação e Predação de sementes da Castanha-do-Pará (Bertholletia excelsa Humb. & Bonpl.) Lecythidaceae e Fatores que Condicionam a Sua Regeneração.

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A castanha-do-pará é, certamente, uma das mais importantes árvores da floresta amazônica. Seus produtos e subprodutos são utilizados há várias gerações, como fonte de alimentação e renda. Estudos recentes sugerem que o ciclo de renovação da espécie foi interrompido e as práticas atuais de coleta não são sustentáveis em longo prazo. Ou seja, árvores velhas não estão sendo substituídas por exemplares jovens devido à coleta excessiva de seus frutos. Entretanto, em ambientes pouco antropizados, encontramos o mesmo problema: poucos indivíduos jovens na sua estrutura populacional. Uma das possíveis explicações para esse fato é que a população de animais como, por exemplo, cutias estão predando demasiadamente estas sementes, sendo até sugerido o controle populacional desses animais. Dentro desse contexto, homem e animais interferindo na estrutura populacional da B.excelsa, objetivaram-se saber a taxa de germinação e predação de sementes dessa espécie na FLONA Tapajós, onde, supostamente, não há coleta dos frutos, e em áreas sobre influência antrópica. As sementes foram plantadas na FLONA em maio de 2004. Foram colocados ouriços presos a barbantes e fixados a grampos presos no solo da floresta. Estão sendo feitas também entrevistas com pequenos produtores e levantamento de castanheiras em suas propriedades e em áreas do mesmo tamanho dentro da FLONA Tapajós. Os dados coletados até agora tem nos mostrado um índice muito grande de predação, tanto nas sementes plantadas, como nos ouriços introduzidos na floresta. Ainda não foi constatada germinação de sementes devido ao grande período que as mesmas levam para germinarem no seu ambiente natural.

ND (Nutrient Dynamics)

14.1-P: Spatial patterns in limnological parameters and bathymetry in Lago Grande de Curuai, a large floodplain system in the lower Amazon

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Lago Grande de Curuai, located along the Amazon River near Óbido, is approximately 2000 km² and comprised of a set of interconnected lake basins. The flooding dynamics is characterized by four stages: a period of rapid rise (over 3.6 cm d-1) in January and February; a period of overflow from April through June when water usually overtops the levees; a period of rapid fall from August to October; and a period of low water level from October to December. To characterize spatial heterogeneity in limnological conditions in situ measurements were made at 210 stations and samples were collected for laboratory analyses at 70 stations. Ordinary kriging was used to model and describe spatial patterns. A time-series of Landsat data, classified by water color with validation based on in situ measurements of limnological parameters and surface reflectance spectra, offered synoptic images of spatial patterns. To aid interpretation of these patterns, a comprehensive bathymetric survey was conducted and a digital elevation model of the lake basins developed.

14.2-P: Effects of land use changes on the chemistry of small streams in the Cerrado region

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Many studies have linked the degradation of surface water quality with the clearing of native vegetation within the watershed followed by replacement with agriculture or urban settlements. The riparian forests that occur along small streams ("Matas de

Galeria") in the Cerrado region are unique in being quite distinct from the surrounding landscape. Although gallery forests represent a small portion of the landscape, they may be critically important as primary biogeochemical controllers of stream chemistry. Previous research in the Amazonian region has in fact indicated that riparian and aquatic ecosystem might be more important determinants of stream water chemistry than upland terrestrial changes. Replicate first order streams that drain watersheds dominated by natural Cerrado vegetation, agriculture, urban lands, and their surrounding gallery forests, in and around Brasília were selected. Stream water samples were collected during the dry and wet season for determination of pH, conductivity, alkalinity and dissolved oxygen. Values of pH and dissolved oxygen were significantly higher in the dry season than in the wet season except in the native areas. There were no differences between seasons for conductivity and alkalinity. Lower pH values were found in the streams of native areas during the dry season while in the wet season streams in native and agricultural presented values lower than those in urban areas. Conductivity varied along the land uses and seasons with significantly higher values in the urban areas. Alkalinity was also higher in streams in urban areas and there was no difference between native and agricultural areas. Dissolved oxygen concentration did not differ between land uses in the wet and dry seasons.

14.3-P: Identifying Hydrological Flowpaths and Land-Water Nutrient Transformations in Forested and Deforested Watersheds in the Southwestern Amazon: a Multivariate End-Member Mixing Analysis

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Deforestation alters both hydrological flowpaths and the biogeochemical transformations that occur within flowpaths. We used a principal component-based analysis of storm-induced stream water flows to determine the contribution to storm flow by flowpaths in forest and pasture basins (1 ha) in Rondônia. Episodic streams that stop flowing during the dry season drain both basins. Weirs, continuous stage monitors and precipitation collectors were deployed at both sites. Stage-triggered automatic samplers collected stream storm flow for each rain event. Overland flow was collected at one to three locations in each basin. Forest canopy throughflow was collected at twenty locations and shallow (20 cm) and deep (100 cm) soil solution were collected with tension lysimeters at ten locations. Riparian groundwater was collected weekly at three wells proximate to drainage points at each basin. All samples were analyzed for an array of natural conservative ionic solutes and all forms of dissolved inorganic nitrogen. Our mixing analysis suggests that in both pasture and forest, groundwater and shallow soil water were important contributors to stream flow. In the forest, of the six possible flowpaths sampled, riparian groundwater, shallow soil solution and overland flow best explained the chemistry observed; direct throughfall, deep soil water and pipeflow were not important. In the pasture, quick flow path of overland flow played a much more important role in generating stream flows. Comparison of water sources to streams with concentrations of nonconservative ammonium and nitrate yielded high rates of ammonium consumption and nitrate production in quick, near-surface flowpaths. This approach has great potential to determine not only changes to hydrology but the transformations of nutrients moving from land to water that result from large-scale changes to land use.

14.4-P: Carbon, forest structure, soil and hydrological relationships in a primary forest undergoing reduced impact logging in southern Amazonia

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Record rates of deforestation in 2004 in the frontier regions of Amazônia, and a consistent increasing trend since 1996 (INPE 2005), have led to major changes in land-cover/land-use. Advances in sustainable logging using reduced impact techniques (RIL) could substantially decrease stand damage and carbon loss. We studied relationships between primary forest vegetation, biogeochemistry and hydrology, and the effect of silvicultural RIL on seedling regeneration, soil nutrients, forest structure and coarse woody debris (CWD) in NW Mato Grosso. Tree biomass was significantly greater in upland while liana stem density was higher in lowland positions. Commercial timber species were significantly clustered, with a mean density of 6 trees ha^{-1}. Areas protected from logging as 50 m stream buffers under RIL represented an average of 29% of the total area; an additional 27% of the area had no timber species. A total of 37 species were harvested, with 48% of the total carbon exported from the site in three of the most common species. Logging damage produced 4.9-8.8 Mg C ha^{-1} logged of CWD from all phases of the operation. Carbon export in whole logs (2.1-3.7 Mg C ha^{-1} logged) represented 1-3% of the total standing forest carbon ≥ 10 cm DBH (138 Mg C ha^{-1}). Edaphic physical and chemical composition were extremely variable, with geostatistical analyses indicating strong spatial structure of soil properties over ranges of 65-225 m. Nitrate loss in logged gaps was restricted to < 1 m depth. Our results demonstrate that edaphic and topographical properties, especially soil texture, exert control over tree species distribution in this

landscape.

14.5-P: Leaching of essential nutrient cations and anions from undisturbed lowland forests across the Brazilian Amazon Basin.

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Nutrient leaching plays a key role in the regulation of productivity, sustainability and carbon balance of terrestrial ecosystems, particularly when weathering and atmospheric deposition are limited sources of essential nutrients. While leaching of inorganic (plant available) forms of essential nutrients has traditionally been thought to be regulated by plant demand, leaching of organic forms is less well understood. Controls over nutrient leaching are fundamental to the question of ecosystem sustainability of native forests and how these processes might respond to land use and climate change. Recent work has focused on the controls of organic and inorganic nitrogen (N) leaching in temperate ecosystems which are putatively N limited. We examined losses of both N and phosphorus (P) in tropical lowland forests occurring on N-rich and P-poor soils. Our study sites span 10 degrees of longitude across the Brazilian Amazon. While total rainfall and mean annual temperature do not vary significantly (26- 26.7 ºC and 2000-2200 mm respectively), seasonal distribution of rainfall and soil class do vary. As expected, total N concentrations in stream water were relatively high (50- 650 ppb N). Both total N concentration and proportion of N in organic form increased as we moved westward across the sites, correlated to an increase in the length of the dry season. Most streams showed a significant pattern of decreased NO3-N concentration in the dry season with no seasonal pattern for NH_4-N or organic N. In contrast measured P concentrations were very low (0.5 to 2 ppb P) and consistent across shifts in seasonality and soil development. Phosphorus leaching was strongly dominated by organic forms with inorganic P rarely reaching detection limit. The highest concentrations of mineral nutrient cations (Ca^{2+}, Mg^{2+}, and K^{+}) occurred in streams on the least developed soils (Alfisols) with much lower levels found in streams located in more developed soils (Ultisols and Oxisols). Our results suggest we need to consider climate and soil development as important regulators of nutrient losses from undisturbed terrestrial ecosystems.

14.6-P: Volume e conteúdo de nutrientes na liteira grossa em áreas sob manejo florestal

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Foram avaliados o volume de necromassa (Ø >2 cm) e os seus estoques de carbono e nutrientes em uma floresta primária não-explorada (testemunha), em três idades posteriores ao corte florestal (2, 6-7 e 11-12 anos), no noroeste de Mato Grosso. A necromassa total foi de 33,7 Mg.ha-1 na floresta intacta e de 20,6, 19,9 e 26,4 Mg.ha-1 nas áreas submetidas à exploração florestal (2, 6-7 e 11-12 anos, respectivamente). A principal alteração em decorrência da exploração florestal foi o aumento no estoque (105 %) e no volume (37%) de liteira com diâmetro de 2 a 10 cm. Apesar de representar apenas 7-16 % da necromassa total (devido a baixa densidade da madeira: 0,2 g.cm3), foi responsável por 36-56% do volume de liteira grossa. Nas áreas não-exploradas, apesar desta fração (2-10 cm) representar apenas 7% da massa total, armazena 16% do N, 25 % do P e Ca, e 19% do Mg estocados em toda liteira grossa. Nas parcelas com 2 anos após o corte, houve aumentos substanciais nos estoques de carbono e nutrientes na fração com diâmetro de 2-10 cm: o carbono aumentou 140%, representando 16,5% do carbono total estocado na liteira; N, K, e Mg passaram a ter 33, 40 e 35%, respectivamente, do seu estoque na liteira de 2 a 10 cm. Portanto, o material mais fino da liteira grossa (fração com Ø 2-10 cm) possui uma importante função ecológica devido às suas concentrações de nutrientes mais altas, rápida decomposição e incorporação, o que provavelmente favorece a regeneração natural após a exploração florestal.

14.7-P: Comparison between properties of superficial horizons of a Oxisol under different land use/land cover in northeastern Rondônia, Brazilian Amazon

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Land use may cause important alterations in soil properties. This paper compared the characteristics of a Xanthic Udox soil under pasture, perennial agriculture, and forests. The study area belongs to Machadinho d'Oeste, northeastern Rondônia. In all cases, topography was flat, soil type was Ochric Epidendon, and texture class is loam or clay, with low natural fertility. Epidendons were sampled at 0 to 0.10 meters deep, being four under forests, eleven under pasture, and six under perennial agriculture, mainly coffee and guaraná. Analyses included F tests (ANOVA) and Tukey tests.Soil density was lower under forests when compared to soils under pasture, indicating compactation due to animal grazing. Intermediate values were found for soils under perennial agriculture. No significant statistical difference was found for Carbon content (C), humin (HUM), humic acid (FAH), and fulvic acid (FAF), but their coefficient of variation were lower in soils under forests. The ratio (FAH+FAF/HUM) was lower in pastures, indicating predominance of the HUM fraction, which is more stable. Acidity and S amount were higher in soils under forests. The amount of Calcium, Magnesium, and bases saturation were higher in coffee plantations. No significant differences were found in

the amounts of P, Mg, Na, Cu, Fe, Zn, and B. Although physical alterations are more evident in pasture lands and chemical alterations are more evident in agricultural lands, it is important to emphasize that land management plays a central role in producing changes in soil properties.

TG (Trace Gases)

15.1-P: Comparison of CO mixing ratios at a primary forest and Maxaranguape sites

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This work describes a comparison of CO mixing ratios at a forest site, Santarém km 67 (3S; 54.5W) and a typical region of pristine air in the north-east coastal region of Brazil (Maxaranguape, 5.8S; 35.2W). One year of almost continuous CO measurements, convering entire periods of the dry and wet season, are described for both sites. These CO measurements are part of the Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA). The mixing ratios obtained at Santarém are always larger than those obtained at Maxaranguape. For example, for a typical month of the wet period (April), the CO average was 86.4 ± 8.6 ppbv, at Santarém, and 51.1 ± 9.2 ppbv at Maxaranguape. As expected, a clear increase in CO mixing ratios was observed during the dry season, however, this period peaks in September/October for Maxaranguape and the southern regions, whereas it peaks in November at Santarém. Thus, at Santarém, the highest CO mixing ratios were obtained in November (317 ± 202 ppbv), whereas at Maxaranguape they were 50.1 ± 10.5 ppbv in November (and 59.8 ± 16.1 ppbv in September). It is also noticeable that the seasonal amplitude of variation is much larger at Santarém than at Maxaranguape. Backward trajectories obtained to determine the origin of air parcels reaching Santarém, show predominance of origin from north-east regions. Thus, in addition to the high density of local fires in the Santarém area in November, the arriving air parcels have traveled many days over areas of intense burning.

15.2-P: Availability of Nitrogen and N2O Flux From Pasture Soil After Herbicide Application

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Nitrous Oxide (N2O) is an important greenhouse gas, with high global warming potential and long half-life in the atmosphere. A large portion of N2O natural flux occurs from oceans and the remaining results mainly from the contribution of microbiological processes (nitrification and denitrification) occurring in tropical soils. The nitrogen (N) availability for metabolic processes of microorganisms can be an important factor controlling nitrous oxide emissions (N2O) in those soils. The goal of this study is to improve the understanding of the N2O flux controls from pasture in the Amazon. We investigated the effects of N availability, carbon (C) and N2O emission and soil moisture in soil from two different pastures. The study was developed under laboratory conditions by incubating soil samples from the following pastures: (i) Control - Soil from a traditionally-managed pasture established in 1983 consisting of a mixture of Brachiaria brinzantha and Panicum maximum, with the presence of weeds; and (ii) Herbicide - Application of an herbicide to a pasture established in 1983 to eliminate vegetation planted with no-till rice and planted posteriorly with forage grass. It is important to note that soil samples (0-5 cm depth) were collected on the third day after herbicide application. To compare and understand N2O fluxes, before incubation we added nitrate, dextrose and water to the soil and used acetylene to block N2O oxidation to N2, in order to estimate the N2 ratio emitted from the soil. The highest fluxes were observed when nitrate was added to the soil under high moisture conditions. The dextrose addition (C source) elevated fluxes intensively in soil from the pasture that received the herbicide application and also displayed higher N availability. With the acetylene application it was possible to see that a large part of N lost in gaseous forms occurs as N2. Thus, in the studied pasture the denitrification process appeared to be dominated by N2O ground fluxes and N was the main control factor of these fluxes.

Key Words: nitrous oxide, Amazon, denitrification, gas fluxes, greenhouse effect, global warming.

15.3-P: A Preliminary Evaluation of Concentrations of Trace Gases in a Clay-Rich Yellow Latosol in the Tapajos National Forest

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The Tapajos National Forest-TNF, a conservation area with 600,000 ha of protect forest, lies 50km from Santarem, Para, Brazil. The soils are highly weathering and deep, well drained, kaolinitic,Yellow Latosol in Brazilian soil classification system (Oxisols in the US system). The soils are acid (pH ~4.5) and they lack hard pans or lateritic concretions. Stainless steel tubes were installed in lateral walls of the three profiles at depths of 0.05, 0.15, 0.30, 0.50, 1.0 and 2.0 m to collect soil gases (CO2, N2O, CH4). Gases were analyzed by ECD and FID gas chromatography. The chromatograph was calibrated with 3 synthetic air mixture standards referenced to the CMDL LBA calibration standards. At 15cm we observed higher concentrations during the wet season than dry season; at others depths the opposite is true. This suggests that soil moisture is sufficient to promote the gas trace production and emission, while not restricting their internal diffusion. We found significant correlations between soil moisture and gas concentrations up to 30cm depth.

15.4-P: Using the super-parameterization concept to include the sub-grid plume-rise of vegetation fires in low resolution atmospheric chemistry-transport models

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We adopt the super-parameterization concept to include the vertical transport of hot gases and particles emitted from biomass burning in low resolution atmospheric-chemistry transport models. This sub-grid transport mechanism is simulated imbibing a 1D cloud resolving model with appropriate lower boundary condition in each column of the 3D host model. Through assimilation of remote sensing fire product, we recognize which column has fires, using a land use dataset appropriate fire properties are selected. The host model provides the environment condition and, finally, the plume rise is explicitly simulated. The final height of the plume is then used at the source emission field of the host model, releasing material emitted at flaming phase at this height. We compare model results with 500 mb AIRS carbon monoxide data for September 2002 and show the huge impact that this mechanism has at the model performance.

15.5-P: Vertical profiles of carbon dioxide and other trace gas species over Amazon basin using small aircraft

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Since December 2000 vertical profiles of CO2, CH4, CO, H2, N2O and SF6 have been measured above central Amazônia, over Tapajós National Forest (near Santarém), and since 2004 over Cuieiras Biological Reserve (near Manaus), and from 2001 to 2003 above Fortaleza on the Brazilian coast. Samples are collected aboard light aircraft between the surface and either 4 km (Para and Amazonas) or 5 km (Fortaleza) using the NOAA/CMDL semi-automatic portable flask package (PFP). The PFP consists of 17 glass flasks with 750 mL volume that are pressurized to about 3 bar to enable measurements of all the gases mentioned above. Until the end of 2003 the PFP's were sent from Boulder, Colorado to Brazil, where they are filled, and then sent back to Colorado for analysis. A replica of the NOAA/CMDL trace gas analysis system was constructed and installed in IPEN/LQA starting in May 2004. The equipment set up in Brazil is capable of high-accuracy and high-precision measurements of CO2, CH4, CO, N2O and SF6 in the flask and PFP samples.

We have compared our vertical profiles of all species to the NOAA/CMDL background site Ascension Island (ASC) located in the Atlantic Ocean (8°S). CO2 profiles at Santarém tend to be depleted at all altitudes during the wet season, and somewhat enhanced during the dry season. However, over the course of 4.5 years, we have relatively few dry season profiles. CH4, on the other hand, is enhanced in all seasons. Presumably, this is due to wetland emissions during the wet season and burning during the dry season. The wet season enhancement of N2O in the boundary layer appears to have increased over the last several years, possibly due to an increase in the application of fertilizer for agriculture around Santarém. CO is also enhanced at lower levels, but most prominently in the dry season. Although our measurement record at Manaus is much shorter than Santarém, there are preliminary indications of urban influence in the air above the km-34 tower. At both Manaus and Santarém, two sets of profiles are taken: near Manaus, above the km-34 tower and 100 km to the east; and near Santarém, above the km-67 tower and 50 km to the east above partially agricultural land. In both cases, we will analyze the different profiles with respect to possible anthropogenic influences on our observations.

15.6-P: Soil-Atmosphere Carbon Dioxide and Methane Fluxes in Undisturbed Tropical Forest

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Carbon dioxide (CO_2) fluxes measured at the soil surface are the net result of many biological below ground and surface processes that remineralize organic matter. Methane (CH_4) fluxes result from the balance between its production and oxidation. Soil temperature and moisture exert strong controls on the soil-atmosphere exchange of trace gas fluxes. We measured the soil-atmosphere flux of CO_2 and CH_4 with an automated chamber system from April 2001 through October 2004 in the Tapajos National Forest, Para, Brazil. This is a mature forest on a clay Oxisol. The mean annual temperature is 25°C with diurnal range often exceeding the variability in the annual daily means. The mean annual precipitation is ca. 2000 mm per year with a distinct dry season from July to December. Eighteen aluminum chambers were installed in a 0.5 ha area close to the flux tower at the km 67 LBA site. Eight chambers were sampled about 5 times per day (closed 7% daily) and the other 10 chambers were each sampled approximately once per day (closed 1.5% daily). For the 8 frequently sampled chambers, dry season fluxes over the three year period averaged 2.5 μmol CO_2 m^{-2} s^{-1} and the wet season averages were 3.0 μmol CO_2 m^{-2} s^{-1}. As expected, the drained upland soils most often consumed CH_4 at slow rates, but during wet periods, we measured episodic emissions of greater than 20 mg CH_4 m^{-2} d^{-1}.

15.7-P: Estimativa da Emissão de Gases (CH4 e CO2) Pelo Reservatório de Balbina: Com Implicações Junto ao Aquecimento Global

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As usinas hidrelétricas apesar de serem historicamente consideradas como geradoras de energia elétrica limpa, no último ano foram identificadas emissões significativas de gás metano para a atmosfera através da Hidrelétrica de Balbina. Atualmente, são praticamente inexistentes os estudos, concluídos e em atividade, avaliando as emissões sazonais de gases por hidrelétricas. O objetivo do trabalho foi demonstrar uma estimativa preliminar sobre as emissões de GEEs de todo o Reservatório de Balbina e no Rio Uatumã. As emissões de gases foram estimadas utilizando informações de câmaras estáticas e através das concentrações de gases retirados da água. O total estimado para a jusante da barragem em 2004 foram de 0,088 e 0,067 Tg, de gás carbônico e de gás metano respectivamente. Quanto ao gás ebulido pelas turbinas, foi estimado no ano de 2004 foi de 0,044 Tg de gás carbônico e 0,037 Tg. de metano. O Lago de Balbina, a montante da barragem, emitiu cerca de 0,12 e 0,08 Tg de gás carbônico e metano respectivamente. Acrescento que esses valores são preliminares, e o estudo prosseguirá, até o final do ano de 2006, tendo resultados para propor um modelo da emissão de gases para a Hidrelétrica de Balbina. Entretanto, a soma desses valores representou cerca de 10% de todo gás carbônico que é emitido anualmente pela cidade de São Paulo. Isso terá futuras repercussões na contabilidade total do ciclo de carbono e junto aos processos de aquecimento atmosférico da Amazônia.

15.8-P: Characterization of optical properties of the atmospheric aerosol in Amazônia from long-term Cimel measurements [1993-95; 1999-2004]

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In Brazil, we now have a significant data set of ground-based spectral aerosol optical depth measurements from Cimel sunphotometers at several sites distributed across the Amazon basin, with a record including more than 9 years at some locations. This network is the only such long-term program monitoring column aerosol properties available for this region, and provides a unique opportunity to characterize the nature of atmospheric effects on the Amazonian climate.

The multi-year (> 9 years at some locations) statistics and distinctive features of the Amazonian aerosol are presented by partitioning the region into three aerosol regimes; southern Amazonian forest, Cerrado, and northern Amazonian forest. Data presented generally includes the interval from 1999-2004, but some sites date to 1993.

Seasonal trends of aerosol optical depth (AOD), and columnar-averaged microphysical properties of the aerosol derived from sky radiance inversion techniques (single-scattering albedo, volume size distribution, angström exponent, fine mode fraction of AOD, etc.) are described and contrasted for the selected regions.

Particular emphasis is placed on aerosol absorption features during the burning season, and on inter-annual variations. The relationships between site-specific fire count products from the Automated Biomass Burning Algorithm (ABBA) and day-averaged smoke AOD at Alta Floresta, Rondônia are also examined.

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