**B22E-04 1645h**

### Variability of MODIS Albedo for Major Global Vegetation Types

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The global coarse resolution latitude/longitude land surface albedo data sets derived from the Terra MODerate resolution Imaging Spectroradiometer (MODIS) have been completed for use by the global modeling community. This paper describes these Bidirectional Reflectance Distribution Function (BRDF) and Albedo Climate Model Grid (CMG) products and their variability within major global vegetation types. Preliminary results reveal that these coarse resolution global albedos have the spatial and latitudinal patterns appropriate for the underlying IGBP land cover classes, further encouraging modelers to introduce albedos as variants of ground cover, geographic location, temporal season and spatial resolution in the various climate modeling schemes.

**B22E-05 1700h**

### Spectral and Angular Surface Albedo Properties Over the ARM Southern Great Plains Area During Spring 2003 IOP From Combined Ground and Spaceborne MODIS, MISR and Landsat Observations

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Information about surface albedo is required as surface boundary condition for radiative transfer modeling, aerosol retrievals, atmospheric dynamics and cloud simulations. Ground observations also provide ground truth radiation measurements for validation and intercomparison with airborne and satellite data. We present our approach and results for characterization of surface albedo spectral and angular properties during the Atmospheric Radiation Measurement Program (ARM) Spring 2003 Aerosol Intensive Observation Period (IOP) using ground-based and spaceborne combined observations. The results are presented for the ARM Southern Great Plains (SGP) study area. We conducted multiple ground spectral measurements at various locations over typical surface types in the area under mid-May conditions. The results of ground survey of landcover type distribution and Landsat ETM scene were utilized to generate the landcover map at high spatial resolution. The dominating surface types in the area during mid-May were ripening wheat (65 percent) followed by grassland/pasture (25 percent). Satellite MISR and MODIS data over the area were processed together with ground measurements collected with narrow-field-of-view probe to analyze surface anisotropic properties. Impact of the improved surface characterization on radiative transfer is assessed. This research was supported by the US Department of Energy Atmospheric Radiation Measurement Program under grant No. DE-FG02-02ER63351.

**B22E-06 1715h**

### A Model-based Approach to Scaling GPP and NPP in Support of MODIS Land Product Validation

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Global products from the Earth-orbiting MODIS sensor include land cover, leaf area index (LAI), FPAR, 8-day gross primary production (GPP), and annual net primary production (NPP) at the 1 km spatial resolution. The BigFoot Project was designed specifically to validate MODIS land products, and has initiated ground measurements at 9 sites representing a wide array of vegetation types. An ecosystem process model (Biome-BGC) is used to generate estimates of GPP and NPP for each 5 km x 5 km BigFoot site. Model inputs include land cover and LAI (from Landsat ETM+), daily meteorological data (from a centrally located eddy covariance flux tower), and soil characteristics. Model derived outputs are validated against field-measured NPP and flux tower-derived GPP. The resulting GPP and NPP estimates are then aggregated to the 1 km resolution for direct spatial comparison with corresponding MODIS products. At the high latitude sites (tundra and boreal forest), the MODIS GPP phenology closely tracks the BigFoot GPP, but there is a high bias in the MODIS GPP. In the temperate zone sites, problems with the timing and magnitude of the MODIS FPAR introduce differences in MODIS GPP compared to the validation data at some sites. However, the MODIS LAI/FPAR data are currently being reprocessed (=Collection 4) and new comparisons will be made for 2002. The BigFoot scaling approach permits precise overlap in spatial and temporal resolution between the MODIS products and BigFoot products, and thus permits the evaluation of specific components of the MODIS NPP algorithm. These components include meteorological inputs from the NASA Data Assimilation Office, LAI and FPAR from other MODIS algorithms, and biome-specific parameters for base respiration rate and light use efficiency.

URL: http://www.fsl.orst.edu/larse/bigfoot/index.html

**B22E-07 1730h**

### Validation of the MODIS GPP algorithm (MOD17A2) using eddy flux tower data

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We compare satellite-based regional calculations of gross (GPP) primary production from MODIS (MOD17A2) to tower eddy $CO_2$ flux-based estimates across a diverse range of landcover types and climate regimes represented within the Ameriflux network. Recently revised input data, including meteorology from the NASA Data Assimilation Office (DAO; GEOS-4.02) as well as leaf area index (LAI) and fraction of PAR (fPAR) from the MOD15 algorithm (Collection 4), have resulted in improvements of GPP estimates at these sites when compared to previous productivity estimates. Three possible sources of error within the MODIS GPP algorithm are explored. We evaluate the sensitivity of MODIS outputs to input meteorology by using both DAO and site-based daily weather information to calculate the MODIS GPP estimates. Comparing these results provides an independent assessment of the accuracy of the MOD17 algorithm phenology and the ability of the DAO data to capture local meteorology is also tested. The MOD15 LAI/fPAR outputs are also compared with site data to determine additional sources of error. Finally, vegetation parameters within the MOD17 GPP algorithm are examined to determine the effects of these variables on GPP results. Our analysis indicate that MODIS and tower based estimates compare favorably in temperate regions, but that results vary for other regions such as boreal and Arctic regions. The DAO meteorology appears to be responsible for much of the difference between tower-based and satellite-based estimates of GPP, but additional sources of error arise from surface heterogeneity and cloud cover.

**B22E-08 1745h**

### Matching MODIS Products to Flux Towers: the first step in bottom-up scaling

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Bottom-up scaling of tower based ecosystem fluxes to a large region involves several steps. In essence, the bottom-up approach to scaling constitutes a defensible strategy to fill the space between a set of in-situ observational nodes (i.e., the flux towers) with an estimate of the exchange that is matched to measured values at the nodes. To ensure that the space-filling process is responsive to variations of biophysical parameters related to land-cover and ecosystem type, the scaling strategy uses a suitable ecosystem exchange model as its aggregation tool. Here, we apply a bottom-up scaling strategy to gross photosynthetic exchange of carbon dioxide (GPE), and use MODIS derived 8-day composites at a 1 km resolution as the aggregation tool. As a first step in the scaling strategy, the MODIS derived GPE composites must be matched to corresponding estimates from the flux towers, to root them on the flux towers as their observational benchmarks. This paper addresses problems and issues associated with matching MODIS products to flux tower derived GPE at the hand of 7 km x 7 km MODIS product subsets centered on AmeriFlux towers in Indiana (MMSF flux) and Michigan (UMBS flux). Waypoints along our route to achieve matching include, (i) separation of directly measured net ecosystem exchange fluxes into ecosystem respiration and GPE; (ii) high resolution assessment of vegetation indexes (VI) in the area around the flux tower likely to be covered by the flux footprint, based on IKONOS or Landsat scenes. (iii) The high resolution VI will be overlaid with computed flux footprints to examine the area-to-area representativeness of flux measurements over various time scales. In particular, we will examine whether the averaging power of the spatially evolving flux footprint over an 8-day integration period (matching the MODIS time scale) is usually sufficient to provide fluxes with acceptable spatial representativeness to serve as a benchmark for MODIS products. (iv) We will compare the footprint weighted integrations of vegetation index drivers (e.g., NDVI, LAI) to those of the 49 MODIS breakout "pixels" of the 7 km x 7 km subsets. Because of residual uncertainty in the geopositioning of the MODIS pixels, and variations in the flux footprint location, it is not certain which of the 49 breakout elements matches the area in the composite tower flux footprint best. Is it always the same MODIS pixel that achieves the best match? (v) Based on the foregoing, we will examine the ratio of the MODIS derived flux to the measured flux under the condition that the footprint weighted vegetation index matches that of MODIS (i.e., by using a selection of data, based on given representativeness criteria). Finally, this analysis will allow us to derive a regression function to calibrate the MODIS derived fluxes to a spatially representative subset of tower flux measurements.

## B31A MCC: 3014 Wednesday 0800h

### Ecosystem Interactions with Land-Use Change I *(joint with H)*

***Presiding:*** **G P Asner,** Carnegie Institution**; R DeFries,** University of Maryland

**B31A-01 0800h**

### Effects of Introduced Grasses, Grazing and Fire on Regional Biogeochemistry in Hawaii

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African grasses introduced for grazing have expanded in geographic extent in mesic tropical systems

of Hawaii and other regions of the world. Grassland expansion leads to increases in fire frequency, speeding woodland and forest destruction at greater geographic scales than occurs with grazing alone. At Pu'uwa'awa'a Ranch, Hawaii, restoration of the native woodland habitat has become a critical objective following the introduction and dominance of the African grass species *Pennisetum clandestinum* and *P. setaceum*. Grazing and grass-fueled fires have destroyed over 60% of the original forest. To stabilize these communities, managers must balance the combined effects of grazing and fire. Grazing reduces the recruitment success of native tropical trees, but grazing also reduces fire risk by moderating grass fuel conditions and restricting the extent and density of the most flammable grass species. Our study focuses on two questions: (1) What grazing intensity is necessary to change the fire conditions of a region given in situ soil and precipitation conditions? (2) Have long-term grazing conditions altered soil carbon and nitrogen stocks? We used high resolution imaging spectrometer data to measure photosynthetic and non-photosynthetic vegetation cover, analysis of soil carbon and nitrogen stocks, and measurements of plant community composition along gradients in grazing intensity. *P. setaceum*, the more flammable alien grass, was dominant where grazing intensity was low and at lower elevations where precipitation is low. The less flammable grass, *P. clandestinum*, occurred in regions of high grazing intensity and higher precipitation. Grazing influenced the dominance of *P. setaceum* and *P. clandestinum* only where precipitation and soil characteristics were suitable for both grasses to occur. At suitable sites, grazing reduced fire conditions through a species sift towards *P. clandestinum*. Soil carbon and nitrogen stocks decreased with grazing intensity, which was correlated with the fractional cover of *P. setaceum*. Soil carbon also increased with precipitation. These results show how grazing impacts fire conditions and soil chemistry through changes in species composition, and not through removal of carbon inputs (direct removal of biomass).

## B31A-02 0815h INVITED

### Integrative Regional Studies in the Mississippi Basin: Investigating the Effects of Land Use / Land Cover Change on Land and Water Resources

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Over the last two hundred years, much of the Mississippi basin has been converted from forest, savanna and grassland to mosaic of agricultural and urban areas. Furthermore, technological changes – especially those dealing with agricultural practices like fertilizer use – have also had a widespread affect on environmental systems in the basin. Taken together, the massive transformation of land cover and agricultural land use practices have had a tremendous effect on the hydrological, biogeochemical and ecological processes occurring within the region. This transformation of the basin has a significant impact on human welfare and that other of other species, primarily through changing the distribution of ecosystem "goods and services" produced there. Here we present results that examine how large-scale changes in land use and land cover of the basin may have affected: (i) large-scale water balance and hydrology; (ii) water quality, especially nitrate concentrations; (iii) ecosystem productivity and carbon storage; and (iv) agricultural yield. In this study, we use a combination of process-based ecosystem models (for both natural ecosystems and agricultural systems), large-scale hydrological routing models, and detailed historical land use and climatic datasets. By comparing the response of different environmental processes to combinations of land use and climatic drivers, we may examine the underlying "resilience" of these ecosystems – and how they may respond to environmental changes. Furthermore, we examine the tradeoffs between ecosystem goods and services – such as a potential balance between increasing crop yields and decreasing water quality – on a regional scale. Such regional-scale integrative studies are only now in their infancy. But they represent a framework for exploring the complex interactions between human societies, local landscapes, and regional environmental processes. Such "place-based" integrative studies should be compared to other regions of the world as well – to see whether more general lessons about ecosystem resilience and human-ecosystem vulnerability may be developed.

## B31A-03 0835h

### Simulations of Decadal-scale Climate Change Impacts on Agriculture: Attributing Trends in Regional Corn Yields to Physiological Effects Versus Adjusted Farm Management

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A recent study published in *Science* in early 2003 [by David Lobell and Gregory Asner, Dept. of Global Ecology, Carnegie Inst. of Washington] highlighted that little effort has been put forth to understand the impacts of previous decadal-scale climate changes on row-crop agriculture. The major obstacle to overcome in quantifying crop response to climate changes over large regions is deciphering between changes attributed to climate change versus technology, land-management and other factors. While the Lobell and Asner study concluded that regional temperature trends potentially contributed to corn and soybean yield trends from 1982-1998, a partitioning of the observed increases between direct physiological effects versus farmer management adjustment to climate was not a goal of their study. As part of this study, an agricultural version of the Integrated BIosphere Simulator (Agro-IBIS), was used to investigate how decadal-scale climate changes may have contributed to corn yield trends across the Mississippi Basin from 1948-2001. The primary objective was to investigate the relative contributions of physiological effects and farmer adjustments in planting date and hybrid choice to long-term corn yield trends. The impacts of advancing technology on agriculture were removed from model simulations so that the impact of weather and farm management decisions (e.g., planting date and hybrid choice) could be separated from observed long-term trends in the USDA crop yield record. Scenarios were used that accounted for smart-farmers, where management adjustments (planting date and/or hybrid) were made in response to climate changes, and for business-as-usual-farmers who continued to plant the same hybrids on the same date during the study period. When average, optimum corn planting dates from the 1950s were compared with the 1990s, significant springtime warming in regions of the northern fringes of the cornbelt (e.g., North Dakota, Minnesota) over the past 40 years have caused optimum corn planting dates to retreat by 6 to 16 days, a trend of up to 0.4 days per year. This simulated result is in accordance with previous studies that confirmed an advance in the growing season in several regions of the globe of approximately 8-10 days during the last several decades. However, the degree of springtime warming appeared to decrease significantly towards the southern boundaries of the cornbelt, as optimum planting dates advanced by 1 to 5 days in a region from eastern Kansas through Missouri and central Illinois and Indiana. Not surprising was the response of a generic corn hybrid (1400 growing degree-days [GDD] to reach physiological maturity) for these two time periods. Clearly, the earlier planting dates over much of the northwest portion of the cornbelt region coincided with a simulated average 0.25 to 3 Mg $ha^{-1}$ increase in corn yield between the two decadal periods. We hypothesize that this region of the Northern Great Plains has likely seen significant changes and trends in management decision-making over the past several decades, most likely in the choice of corn hybrids (GDD to silking and maturity), planting dates, or a combination of the two in response to springtime warming. Therefore, in this region, farmer adaptation to climate trends may have taken precedence over the direct physiological effects of warmer temperatures towards increasing corn production.

## B31A-04 0850h INVITED

### Spatially Distributed Effects of Woody Encroachment on Soil NO emissions From a North Texas Rangeland.

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Woody encroachment, a spatially-explicit process of land-cover change, has produced documented changes to the biophysical and biogeochemical properties of ecosystems. However, little information (none that is spatially distributed) is available on the impacts of woody encroachment on N oxide emissions from savanna regions. We combined hyperspectral remote sensing and field measurements to quantify spatial patterns and estimate regional fluxes of soil N oxide emissions as they co-vary with vegetation cover and soil type across a semi-arid rangeland in North Texas. Soil nitric oxide (NO) emissions were highly correlated with it Prosopis canopy cover, allowing the extrapolation of NO fluxes from hyperspectral observations of woody cover. NO emissions were highly variable, ranging from 0-550 NO-N kg $km^2 y^{-1}$, across the region, with the lowest emissions from shallow clay soils and highest from deeper upland clay loams. A remotely-derived annual NO emission estimate was 122 kg NO-N $^2 y^{-1}$, almost 40% greater than that of the value derived from traditional averaging of field measurements. We conclude that relationships between NO emissions and remotely sensed structure and composition are advantageous for quantifying NO emissions at the regional scale. This study also provides new insight into the role of woody encroachment on biogeochemical processes that are highly variable and otherwise difficult to measure at the regional scale.

## B31A-05 0910h

### Estimating the Uncertainty of Land-use History Reconstructions in the Global Carbon Balance

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B

Human land-use activities have had a marked affect on the land surface. Globally, cropland and pasture occupy more than 30 percent of the land surface, and much of the remaining forest area is in some stage of recovery from prior agriculture or logging. Landscapes are generally a heterogeneous mixture of patches with different land uses and land-use histories. Because of these changes and the potentially long-time scales of ecosystem responses to them, historical information on land-use activities is needed for ecosystem studies of the past, present, and future. Because of limited records globally, much of the information needed must be estimated in reconstructions. In this study, we evaluated the importance of several key aspects of uncertainty in land-use history reconstructions on estimates of the global terrestrial carbon balance. We first constructed an ensemble of global land-use history reconstructions that are consistent with major historical databases, but differ in important parameters unconstrained by these databases. We then propagated the ensemble of reconstructions through a set of ecosystem models, based on MIAMI-LU and ED family of models, to determine annual exchange of carbon between the terrestrial biosphere and the atmosphere. These models have been used previously in assessing the effects of land-use history on the U.S. carbon balance and are underdevelopment for global Earth System applications. Analyses identify the relative importance of key uncertainties in land-use history reconstructions for carbon flux estimates and suggest priorities for future research to reduce these uncertainties. In addition, a "preferred" land-use history product is presented for use in global earth system studies.

## B31A-06 0925h INVITED

### Nutrient Controls over Soil Organic Matter Turnover: Implications for Land Use Effects on Soil Carbon Storage

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A wide variety of land use changes can significantly alter soil carbon pools, to the extent that feedbacks between shifting land use and atmospheric carbon dioxide may have global importance. Land use changes also frequently alter nitrogen and phosphorus availability, both via direct application of fertilizer, and via indirect biogeochemical responses to a changed environment. Both N and P availability are known to constrain decomposition rates and microbial activity in a range of ecosystems, but the effects of changing N and P levels on the large stocks of soil carbon are poorly known. We used a combination of radiocarbon analyses and soil organic matter fractionation techniques in long-term N and P fertilizer plots located in tundra, grassland and forest ecosystems to show that soil carbon responses to shifting nutrient levels are likely to be highly complex, but also potentially dynamic. For example, increasing N and P availability appears to accelerate decomposition of some soil carbon fractions, while simultaneously increasing stabilization and storage of others. These

counteracting responses of the soil C pool often result in no detectable change in total soil C stocks, yet the radiocarbon data clearly show that soil carbon decomposition can be sensitive to shifts in nutrient availability. A number of current models of soil carbon cycling are widely used to simulate and predict soil C responses to changes in land use, but our data suggest that none of these models contains the mechanisms required to simulate the complex relationships between N and P cycling and soil carbon storage.

#### B31A-07 0945h

### How Big is the Problem? Constraints on the Extent of Cheatgrass Invasion in the Great Basin, US

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Land use leading to ecosystem disturbance (eg. grazing, agriculture) in the Great Basin, US has been shown to enhance the spread of invasive annuals, in particular cheatgrass (Bromus tectorum) (Young et al., 1972; Mack, 1981). Cheatgrass can dominate as a monoculture or as an understory to semiarid perennial shrubs. Cheatgrass is problematic because it outcompetes native perennial bunchgrasses and shrubs is highly flammable once senesced, and cannot be grazed after senescence in mid-June. Identification of the regional extent of this invasive is necessary for effective land management and accurate ecosystem models. We have shown previously that timeseries from the 1 km resolution Advanced Very High Resolution Radiometer (AVHRR) can be used to accurately distinguish areas of cheatgrass dominance. Here, we scale down to a series of 10 Landsat TM scenes spanning 1988-2001 and find that similar timeseries analysis can be used to identify cheatgrass at 30 m resolution. Elmore et al. (2003) demonstrated that invasive annuals can be distinguished from native perennials based on their amplified response to rainfall. During wet years, cheatgrass dominated landscapes have much higher density and productivity than native shrub dominated landscapes. Amplified response can be detected with Normalized Difference Vegetation Index (NDVI) timeseries from the AVHRR satellite. We created and verified a regional AVHRR-based map of current cheatgrass extent in the Great Basin, and are refining our methodology to map invasion over the decade of the 1990s. The regional extent map was used to identify large expanses of cheatgrass dominance for further investigation at Landsat TM resolution. We selected a high density cheatgrass corridor between Lovelock and Winnemucca in northwestern Nevada and acquired a series of 10 Landsat scenes for that area. The Landsat scenes were coregistered and radiometrically aligned to a 2001 ETM+ scene. They were then converted to reflectance based on invariant ground control points and NDVI was calculated. To detect the amplified response of cheatgrass dominated areas, we ratio NDVI of a high rainfall year (1995) to a low rainfall year (1992). In the Lovelock area, 156 mm of rain fell from Oct-Apr, 1995. This was 77 mm above the 50-year mean. From Oct-Apr 1992, a below-average 51 mm of rain fell. We took a ratio of 1995/1992 NDVI values and compared areas known to contain >30% live cover cheatgrass based on field observation to areas known to contain only perennial shrubs. Cheatgrass dominated areas had a value of 1.59 +/- 0.02 times higher NDVI in 1995. Native perennial dominated areas had a value of 1.22 +/- 0.01 times higher NDVI in 1995. When we subtract 1995-1992 NDVI values the results are equally significant. Cheatgrass dominated areas have a difference of 0.21 +/- 0.06 NDVI, while native perennials have a difference of 0.08 +/- 0.02 NDVI. This contrast indicates that cheatgrass' amplified response can effectively be mapped at Landsat resolution. We have shown that it is possible to map cheatgrass both at a regional scale with AVHRR as well as at a local scale with Landsat TM. By mapping at the higher resolution of Landsat, it becomes possible track the spread of cheatgrass using the high rainfall years of 1988, 1995, and 1998. Land use drivers of cheatgrass invasion can be identified based on patterns and rates of spread. Finally, landscape response to recent invasion can be modeled when the timing of the invasion is constrained. Elmore, A., J. Mustard, and S. Manning, Ecol. App., v13, 2003; Mack, R., Agro-Ecosys., v7, 1981; Young, J., R. Evans, and J. Major, J. Range Mgmt, v25, 1972

## B31B MCC: 3002 Wednesday 0800h

### The Bioatmospheric N Cycle: Emissions, Deposition and Interactions I *(joint with A, H, AE)*

***Presiding:*** **A Mosier,** USDA Agricultural Research Service**; D Ojima,** Natural Resource Ecology Laboratory, Colorado State University**; S B Weiss,** Creekside Center for Earth Observations**; E Holland,** National Center for Atmospheric Research

#### B31B-01 0800h INVITED

### Biogeochemical and Ecological Effects of Nitrogen Deposition in Western North America

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The unique geographic, demographic, climatic and edaphic conditions of the West determine N deposition rates and biogeochemical and ecological responses to N deposition. In the western United States large regions are exposed to low N deposition levels with interspersed hotspots of elevated N deposition near urban areas or large agricultural emissions sources. Nitrogen emissions also contribute to ozone formation and regional haze and visibility impairment, the latter an effect that is observed in remote sites including several high profile national parks and wilderness areas. Recent studies suggest that N enrichment impacts are generally more important in western terrestrial systems than soil acidification effects. In the Pacific Northwest, California and Colorado sensitive organisms such as lichens and phytoplankton demonstrate deleterious biological effects with N deposition levels as low as 3-8 kg ha-1 yr-1. Increased streamwater nitrate export has been reported from southern California forests and chaparral catchments, high elevation watersheds in the Colorado Front Range, and in the most exposed regions of the southwestern Sierra Nevada. Evidence suggests that in some regions N deposition alters plant community composition, decreases mycorrhizal diversity, and also increases biomass accumulation, carbon allocation patterns and fire frequency. Several factors predispose Western semiarid ecosystems to N saturation as will be demonstrated by the San Bernardino Mountains case study (southern California). Edaphic conditions generally favor high nitrification rates relative to N mineralization. Nitrate from nitrification and atmospheric deposition accumulates in soil and on plant surfaces during prolonged dry periods. Under conditions of chronic N deposition, the N cycle becomes highly open in nature as excess N is exported in runoff and as gaseous emissions from soil. Actively nitrifying soils and temporal asynchrony between the period of plant N demand and nitrate availability are the key factors resulting in large N losses. As a result of this asynchrony, N limitation of tree growth occurs notwithstanding the advanced degree of N saturation. The combined effects of ozone and N deposition also cause major changes in plant carbon allocation and accumulation in the ecosystem, particularly under conditions of fire suppression.

#### B31B-02 0815h INVITED

### Changes in Nitrogen Tropical Deposition Driven by Biomass Burning and Industrialization

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Until few years ago, N deposition studies and the consequences for ecosystems were focused on North Hemisphere, where most of the modern N deposition occurs. Nowadays, the pattern of N deposition has changed over the globe, calling attention to other geographical areas, including tropical regions which were the important pre-industrially(Matson et al., 1999). Substantial increases of NOx and SO2 emissions have been observed in Asia and in some regions of the tropics due to the rapid industrialization, urbanization, and deforestation (Ayers et al., 2000; Lara et al., 2001). Nevertheless,little information is available for developing regions of tropical and sub-tropical areas, where land-use changes are intense and followed by rapid urbanization, associated with a large industrial expansion. Such information is relevant, since recent estimates show that in a near future more than half of N inputs related to energy consumption in the Earth will take place in tropical and subtropical regions (Galloway et al., 1994). In addition, tropical terrestrial and aquatic systems appear to function differently from temperate systems, where N limitation is more severe than in the tropics (Matson et al, 1999). Conclusions based only in studies conducted in temperate regions may not be valid for tropical and sub-tropical regions. In the tropics the annual nitrogen wet deposition range from 2 to 10 kg N/ha/yr (Williams et al., 1997; Lara et al., 2001; IGAC 2003), according to the land cover. Brazil is largely tropical. It is considered a developing country, where developed areas with large urban centers, a large number of industries, and a high-technology agricultural system coexists with developing areas with low-technology and frontier-type agricultural systems and remote regions such as Amazon Basin. These anthropogenic activities are increasing the N wet deposition from an annual rate of 3.0 kg N/ha/yr in remote areas to an annual rate of 5.6 kg N/ha/yr in disturbed regions. If this increasing in the N deposition in Brazil will persist it may affect the nitrogen regional cycle with possible consequences to the ecosystems and to the nitrogen global cycle. References: Ayers, G. P., Leong Chow Peng, Lim Sze Fook, Cheah Wai Kong, R.W. Gillett and P.C. Manins (2000), Atmospheric concentrations and deposition of oxidized sulfur and nitrogen species at Petaling Jaya, Malaysia, 1993-1998, Tellus B, 52, 60-73. Galloway, J.N.; Levy, H.; Kasibhatla, P.S. (1994) Year 2020: consequences of population growth and development on deposition of oxidized nitrogen. Ambio 23, 120-123. IGAC newsletter no. 27, DEBITS special issue, January 2003, IGACtivities Newsletter. Lara, L.B.L.S., Artaxo, P.; Martinelli, L.A.; Victoria, R.L.; Camargo, P.B.; Krusche, A.; Ayers, G.P., Ferraz, E.S.B.; Ballester, M.V. (2001) Chemical composition of rainwater and anthropogenic influences in the Piracicaba river basin, Southeast Brazil. Atmospheric Environment. 35, 4937-4945. Matson, P.A.; McDowell, W.H.; Townsend, A.R.; Vitousek, P.M. (1999) The globalization of N deposition: ecosystem consequences in tropical environments. Biogeochemistry 46, 67-83. Williams, M.R., Fisher, T.R., and Melack, J.M. (1997) Chemical composition and deposition of rain in the central Amazon, Brazil. Atmospheric Environment 31, 207-217.

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### Impacts of N-depostion on biodiversity in a grassland ecosystem

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Nitrogen deposition threatens biodiversity in many ecosystems across the globe, and poses a range of scientific and policy challenges. Grassland ecosystems on nutrient-poor serpentine soils provide a model system for understanding local and regional impacts of N-deposition on biodiversity. A population of the threatened Bay checkerspot butterfly crashed from 3500 butterflies in 1997 to likely extinction in 2003. Non-native annual grass crowded out larval hostplants over much of the habitat, primarily driven by nitrogen deposition from tailpipe emissions of NH3 from 100,000 vehicles per day on a roadway bisecting the habitat. NH3 levels (measured with passive monitors) are elevated adjacent to the roadway, but are near background levels 400 m away. Grass cover was higher closer to and downwind of the road, and hostplant cover was inversely related to grass cover. Results from a first-order model show that N-deposition levels adjacent to the roadway are similar (>10 kg-N ha-1 yr-1) to levels downwind of the heavily urbanized Santa Clara Valley (where grass invasions have led to the extinction of large populations via vigorous grass invasions). This local butterfly extinction is unexpected fallout of the adoption of three-way catalytic converters in 1990s. The only known occurrence of an endangered plant, Pentachaeta bellidiflora, exists west of the freeway and may be at long term risk. Invasions of nitrophilous grasses and other weedy species into N-limited grasslands and shrublands appear to be a common response to increased atmospheric deposition in semi-arid areas.