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.

B31B-03 0830h

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.

B31B-04 0845h INVITED

Trace Gas Emissions in Temperate Forests and Impact of Forest Conversion

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Temperate forest ecosystems play a significant role as sources and sinks for primarily and secondarily active trace gases such as N2O, NO and CH4. In recent decades the magnitude of the biosphere-atmosphere exchange of these trace gases has been substantially altered due to direct and indirect anthropogenic activities. E.g. measurements at different forest sites across Europe exposed to different loads of atmospheric N-deposition clearly show, that N-oxides emissions are positively correlated to N-deposition, whereas CH4 uptake rates are negatively affected. Furthermore, stand properties such as tree species composition as well as stand age have also been demonstrated to strongly affect the exchange of these trace gases. Results of continuous measurements of N-oxide emissions at the Höglwald Forest site, Germany, show that e.g. NO-emissions from a spruce site are approx. 6 fold higher (5-7 kg NO-N ha-1 yr-1) than N2O emissions (0.5-1 kg N2O-N ha-1 yr-1), whereas at an adjacent beech site -stocking on a comparable soil- N2O-emissions are 3-5 kg N2O-N ha-1 yr-1 and NO emissions are 2-2.5 kg NO-N ha-1 yr-1. These results are further supported by microbiological process studies, which show that the forest type can alter the magnitude of the key microbial processes mineralization and nitrification by its effect on soil moisture conditions and substrate quality. However, estimates of trace gas exchange between temperate forest soils and the atmosphere remain fragmentary if the effect of direct anthropogenic management activities such as clear cutting and reforestation are neglected. Therefore, in 1999 we started a multi-year experiment at the Höglwald Forest, Bavaria, in which we investigated the effect of the conversion of a spruce forest into a beech forest either by clear cutting or selected cutting on N2O, NO and CH4 emission/ deposition. The results of this study show, that clear cutting strongly enhanced N2O emissions from approx. 0.5 kg N2O-N ha-1 yr-1 to $>$ 5 kg N2O-N ha-1 yr-1 not only for one year but for several consecutive years, whereas NO emissions remained at an high level in the year after clear cutting ($>$ 5 kg NO-N ha-1 yr-1), but declined thereafter. CH4 uptake decreased sharply after clear cutting to values close to zero and did not recover even 4 years after site management. If our results are extrapolated for a typical rotation span of a plantation (80-100 years), it becomes evident that increased rates of N2O losses and reduced rates of CH4 uptake within the first decades of forest conversion will reduce the net greenhouse gas balance of forests -including the net ecosystem exchange of CO2- by up to 35 percent. Compared to these dramatic effects, selected cutting exhibited only in the first year significant effects on exchange rates of N2O-, NO- and CH4, thus, indicating that this forest management practice is more sustainable with regard to the protection of the atmosphere.

B31B-05 0900h INVITED

Land Use Change Effects on Nitrous Oxide Emissions in Tropical Regions

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Soil emissions of nitrous oxide (N_2O) are the single most important natural source for this gas and also the single largest anthropogenic contribution to the global budget of N_2O. The availability of oxygen, inorganic nitrogen, and organic carbon are the three principle limitations to soil emissions of N_2O. These limitations play the same roles in soils globally, so there is nothing intrinsically different about processes in the tropical regions versus the temperate and boreal zones. However, the tropical regions are a far more important natural source of soil derived N_2O and will increase greatly in importance for anthropogenic emissions in the future. Both the area dedicated to agriculture and the quantity of nitrogenous fertilizer applied are relatively stable in the temperate zone while they are increasing rapidly in the tropical zone. When considering N_2O emissions, there are two important eco-regions in the tropics, savannas and forests. In both of these regions, natural ecosystems are being converted to pasture lands and to intensive agriculture. N_2O emissions from natural savannas are minimal. Conversion to pasture and to agriculture has limited effects. In savanna systems the natural limitation of nitrogen and the abundance of oxygen combine to minimize N_2O emissions from soils. In the forested regions, the situation is different. Tropical forests, particularly in humid areas, are nitrogen rich. Conversion of forests to pastures may lead to a brief pulse (from a few months to a decade) of elevated nitrous oxide emissions. Unless pastures are fertilized, their emissions are generally far below native forest emissions of N_2O. Where N fertilizer use is heavy, conversion of forests (or pastures) to agriculture may lead to significant increases in N_2O emissions. But under extensive management or careful intensive management, it is possible for agricultural systems in the humid tropics to have lower N_2O emissions than native ecosystems.

B31B-06 0915h INVITED

Trace Gas and Carbon Sequestration Dynamics in Temperate Croplands and Successional Ecosystems: A Full-Cost Accounting

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Agriculture is responsible for 21-25% of the global anthropic CO2 flux, 55-60% of the anthropic CH4 flux, and 65-80% of the anthopic flux of N2O. A number of CO2 stabilization strategies target agricultural production practices, and the potential for simultaneously abating fluxes of the non-CO2 greenhouse gases is substantial. But so is the potential for creating greenhouse gas (GHG) liabilities, the unintentional increase in one or more GHGs by activities that mitigate another. Whole-system accounting provides a means for including all GHG-contributing processes in the same cropping system analysis in order to illuminate major liabilities and synergies. We contrast a field crop system in the upper U.S. midwest with unmanaged successional ecosystems in the same landscape, and provide evidence that N2O flux - the major contributor to radiative forcing in row-crop systems - can be abated with little loss of crop productivity.

B31B-07 0930h INVITED

DAYCENT Model Assessment of Land Use Change and Management on C and N Fluxes in the USA Great Plains

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Land use changes have dramatically altered the biogeochemical cycling associated with greenhouse gas (GHG) fluxes. During the past 100+ years approximately 60% of the Great Plains grasslands have been converted to crop production. This has resulted in increased N_2O emissions, decreased CH_4 uptake, and depletion of soil organic matter (SOM). However, appropriate use of land management can reduce GHG gas emissions from agricultural systems while maintaining or increasing crop yields. In recent years improved management systems have been introduced which conserve and enhance SOM. The DAYCENT ecosystem model was used to compare the effects of converting Great Plains grasslands to crop production and the effects of different management on net GHG fluxes (GHG_{net}) and crop yields for agricultural systems in the Great Plains of the USA. Improved management includes conversion from intensive tillage to no-till cultivation, and reduction of summer fallow periods by replacing continuous winter wheat cropping with alternative rotations that are economically viable for different climate regimes within the Great Plains. Changes in soil organic carbon, N_2O emissions, CH_4 uptake, CO_2 fluxes, and the CO_2 costs of N fertilizer production were converted to a common unit of CO_2-C equivalents and summed to obtain GHG_{net}. At the regional level, grassland systems are neutral or small GHG_{net} sinks, dryland agriculture is a source, irrigated agriculture is a minor sink, and improved management is a major sink.

B31B-08 0945h INVITED

A Science Plan for Integrated Studies of Coupled Biosphere-Atmosphere Carbon and Nitrogen Cycles

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Human activities, such as the burning of fossil fuels and the use of nitrogen fertilizers, have approximately doubled levels of reactive nitrogen in the biosphere. This perturbation has the potential to alter fundamental processes in terrestrial ecosystems where composition, diversity, and productivity are largely controlled by the availability of nitrogen. A variety of theoretical and experimental studies indicate that nitrogen inputs have a direct impact on fluxes of carbon into ecosystems controlling both CO2 assimilation and the exchange of carbon-based trace gases. In some systems, plant growth and carbon storage appear to be enhanced by nitrogen addition. In contrast, other systems exhibit stagnant or declining plant growth with nitrogen addition as the ecosystem becomes N-saturated and susceptible to stressors such as soil acidification and ozone damage. The magnitudes of the nitrogen and carbon responses appear to depend directly on the pathway and magnitude of nitrogen flux into ecosystems. However, the pathway of nitrogen entry into ecosystems, the chemical species of that nitrogen and its level of incorporation into plant and soil biomass pools are poorly understood in many, if not all, ecosystems. A workshop was held in Boulder, Colorado, in November 2003 to develop a science plan to address the critical need to integrate leaf-level plant physiology, ecosystem, and atmospheric chemistry perspectives to determine the fate of nitrogen and thus carbon in terrestrial systems. Participants brought expertise in plant physiological ecology, biochemistry, soil microbiology, biogeochemistry, atmospheric chemistry, biosphere/atmosphere fluxes, and integrated modeling. On behalf of all participants, we present here the prioritized results of the workshop; including gaps in understanding, technological challenges of integrating biological, ecosystem and atmospheric compartments of carbon and nitrogen cycling, feedbacks in carbon and nitrogen cycle coupling that are likely to produce non-linear responses in the earth system, and identified resource needs for near-term research aimed at reducing uncertainties.

B31C MCC: Level 1 Wednesday 0830h

Carbon Cycling in Northern Soils and Surface Waters III Posters *(joint with H)*

Presiding: **J J Carrasco,** U.S. Geological Survey**; R G Striegl,** U.S. Geological Survey**; K P Wickland,** U.S. Geological Survey

B31C-0301 0830h POSTER

Rhizosphere C flux from tree roots to soil: spatial and temporal differences between sugar maple and yellow birch saplings

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