B42C-0161 1330h INVITED POSTER

Projecting the Future of the U.S. Carbon Sink

George C Hurtt[1] (603-862-1792; george.hurtt@unh.edu); Stephen W Pacala[2] (steve@eno.princeton.edu); Paul R Moorcroft[2] (paul@eno.princeton.edu); John P Caspersen[2] (jpc@eno.princeton.edu); Elena Shevliakova[2] (elena@eno.princeton.edu); Richard A Houghton[3] (rhoughton@whrc.org); Berrien Moore[1] (b.moore@unh.edu)

[1]University of New Hampshire, Institute for the Study of Earth, Oceans and Space, Durham, NH 03824, United States

[2]Princeton University, Department of Ecology and Evolutionary Biology, Princeton, NJ 08544

[3]Woods Hole Research Center, Woods Hole, Woods Hole, MA 02543, United States

Atmospheric and ground-based methods agree on the presence of a carbon sink in the coterminous U.S. (U.S. minus Alaska and Hawaii), and the primary causes for the sink have recently been identified. Projecting the future behavior of the sink is necessary for projecting future net emissions. Here we use two models, the Ecosystem Demography Model (ED) and a second simpler empirically-based model (Miami-LU), to estimate the spatio-temporal patterns of ecosystem carbon stocks and fluxes from 1700 to 2100. Our results are compared to other historical reconstructions of ecosystem carbon fluxes, and to a detailed carbon budget for the 1980s. Our projections indicate that the ecosystem recovery processes that are primarily responsible for the contemporary U.S. carbon sink will slow over the next century resulting in a significant reduction of the sink unless other new sink mechanisms compensate. Key uncertainties in model estimates and priorities for reducing uncertainties will be highlighted and discussed in the context of both the U.S. carbon budget and the likely future of the U.S. carbon sink.

B42C-0162 1330h POSTER

U.S. Timber Harvest from 1750 to 1997

Linda A Joyce[1] (970-498-2560; ljoyce@fs.fed.us)

David Coulson[2] (970-498-2576)

A. David McGuire[3] (907-474-6242; ffadm@uaf.edu)

Brad Smith[4]

[1]Rocky Mountain Research Station, 240 West Prospect, Fort Collins, CO 80526, United States

[2]MATCOM, 240 West Prospect, Fort Collins, CO 80526, United States

[3]USGS, Department of Biology and Wildlife University of Alaska-Fairbanks, Fairbanks, AK 99775, United States

[4]USDA Forest Service, SPPII, RP-C 4th Floor P.O. Box 96090, Washington, DC 20090, United States

Understanding the impact of climate change and the role that carbon sequestration in forests can have on the global carbon cycle will require a fuller understanding of the impact of land use on forests. Ecological models examining the impact of climate change have, until recently, focused on potential vegetation. This inability to incorporate land use data is related to a lack of information on the historical land use patterns. We accumulated the reported historical information on harvested acres, the harvest practice, volume of growing stock inventory, and removals. Land management has had a significant impact on the volume per acresince 1955, volume per acre has increased in nearly all of the 50 states. Forest management for softwoods has traditionally involved harvests that remove most, if not, all of the trees. Hardwood management involves more selective cutting; thus harvest is not a stand-resetting event typically. Data on harvested acres is biased towards recent years, 1970 to present, where as growing stock and removal volume data are available to 1955. To develop harvest information further back in time, we developed two approaches to estimate harvested acres using the available data: 1) an analytical approach based on volume, removals and timberland acres, and 2) a statistical model based on reported harvested acres and their relationship to removals. To extrapolate to 1750, we used settlement information and assumptions about land use. We explore within-state spatial patterns generated by these methods for North Carolina. The methods we used provide a means of assessing uncertainty in historical patterns of land use and of volume of timber removed from forestland across the United States.

B42D MC: 122 Thursday 1330h

Water, Energy, and Carbon Cycles in Terrestrial Systems: Local-Scale Observations Through Fluxnet and Other Micrometeorological Tower Sites II *(joint with H)*

Presiding: **L Gu,** University of California at Berkeley**; D Baldocchi,** University of California, Berkeley**; S W Running,** University of Montana

B42D-01 1330h

How Different are Carbon Cycling and Micrometeorology in Amazon Tropical Forests Compared to Those in Temperate Forests?

Bart Kruijt[1] (31-317-474331; b.kruijt@alterra.wag-ur.nl); Antonio Donato Nobre[2] (anobre27@yahoo.com); Alessandro Araujo[2] (carioca@inpa.gov.br); Celso Von Randow[3] (randow@cptec.inpe.br); Paulo Jorge Oliveira[3] (pj_oliveira@bol.com.br); Antonio Carlos Lola Da Costa[4] (lola@ufpa.br); John Gash[5] (jhg@ceh.ac.uk); Patrick Meir[6] (p.meir@ed.ac.uk); Yadvinder Malhi[6] (y.malhi@ed.ac.uk); Pavel Kabat[1] (p.kabat@alterra.wag-ur.nl)

[1]Alterra, P.O. Box 47, Wageningen 6700 AA, Netherlands

[2]INPA, Manaus, AM, Brazil

[3]INPE/CPTEC, Caxoeira Paulista, SP, Brazil

[4]UFPA, Belem, PA, Brazil

[5]CEH, Wallingford, United Kingdom

[6]University of Edinburgh, Edinburgh, United Kingdom

Tropical rain forests, so far poorly represented within FLUXNET, are often considered 'special' among the forests of the world. Often cited distinguishing aspects are their height, species richness, density, darkness, or humidity. While many of these observations are beyond doubt, we ask the more restrictive question whether these forests are essentially different from temperate ones in their interaction with the atmosphere.

The Large Scale Biosphere-Atmosphere experiment in Amazonia (LBA) and its predecessors are providing some insight into forest-atmosphere exchange, carbon and water cycling. Multi-year flux measurements at several sites so far suggest a (controversially) high net rate of annual carbon uptake and clear seasonality. If compared to other FLUXNET forest sites, variation in uptake seems to be controlled by rainfall as opposed to by radiation in other forests. If we consider in-canopy turbulence and micrometeorology from earlier work, Amazon forest appears somewhat extreme in damping turbulence at best. Finally, if we compare in-canopy photosynthetic properties and physiology, those forests seem fairly ordinary compared to temperate forests.

URL: http://lba.cptec.inpe.br/lba/indexi.html

B42D-02 1345h

Net CO_2 Exchange Over Contrastive Deciduous Forest Ecosystems in Japan: Responses to Temperature Variability

Nobuko Saigusa[1] (81-298-61-8369; n.saigusa@aist.go.jp); Susumu Yamamoto[1]; Minoru Gamo[1]; Shohei Murayama[1]; Hiroaki Kondo[1]; Yasumi Fujinuma[2]; Takashi Hirano[3]

[1]National Institute of Advanced Industrial Science and Technology, AIST Tsukuba West, Tsukuba 305-8569, Japan

[2]Center for Global Environmental Research, National Institute for Environmental Studies, 16-2 Onogawa, Tsukuba 305-8506, Japan

[3]Graduate School of Agriculture, Hokkaido University, Kita-ku, Sapporo 060-8589, Japan

The deciduous broadleaf forests dominated by oak species are widely spread in Japan, Korea, and northeastern China. Deciduous conifer forests consisting of larch species are broadly distributed on the Eurasian Continent, especially in eastern Siberia. These ecosystems are two of the major vegetative constituents of eastern Asia, and they are considered to be important ecosystems that exhibit strong seasonality of terrestrial carbon sink and source in the Eurasian Continent.

The main objective of this study is to estimate the sensitivity of the carbon budget of the ecosystems to climatic conditions. Fluxes of CO_2, water vapor, and sensible heat are measured by the eddy covariance method over two different forest ecosystems: a cool-temperate deciduous broadleaf forest in a mountainous region of Takayama (central Japan), and a larch (deciduous conifer) forest in a flat region of Tomakomai (northern Japan). The Takayama site (36° 08' N, 137° 25' E, elevation 1,420 m) was established in 1993 with the cooperation of the National Institute of Advanced Industrial Science and Technology and Gifu University. The Tomakomai site (42° 44' N, 141°31' E, elevation 115-140 m) was established in 1999-2000 by the National Institute for Environmental Studies and the Hokkaido Regional Forest Office.

Analyses are mainly focused on environmental controls of nighttime and daytime CO_2 exchanges at the different forest ecosystems. An unusually high air temperature anomaly was widely observed at East Asia in 1998, and it caused 20-25 days earlier leaf emergence of most deciduous forests in Japan. However, increased temperature in 1998 summer resulted in the less carbon uptake at Takayama site. It was also suggested that the larch forest in Tomakomai had a high sensitivity to temperature, and the daytime decline in CO_2 uptake with temperature above the optimum was greater in Tomakomai (a larch forest in a flat ground) than in Takayama (a broadleaf forest in a mountainous region).

B42D-03 1400h

Biometric and Eddy-covariance Based Estimates of Ecosystem Carbon Storage in Five Eastern North American Deciduous Forests.

Peter S. Curtis[1] (614-292-0835; curtis.7@osu.edu); Paul J. Hanson[2]; Paul Bolstad[3]; Carol Barford[4]; J. C. Randolph[5]; Hans Peter Schmid[6]; Kell B. Wilson[7]

[1]The Ohio State University, Department of Evolution, Ecology, and Organismal Biology, Columbus, OH 43210-1293, United States

[2]Oak Ridge National Laboratory, Environmental Sciences Division, Oak Ridge, TN 37831-6422, United States

[3]University of Minnesota, Department of Forest Resources, St. Paul, MN 55455, United States

[4]Harvard University, Department of Earth and Planetary Sciences, Cambridge, MA 02138, United States

[5]Indiana University, School of Public and Environmental Affairs, Bloomington, IN 47405, United States

[6]Indiana University, Department of Geography, Bloomington, IN 47405, United States

[7]National Oceanic and Atmospheric Administration, Atmospheric Turbulence and Diffusion Division, Oak Ridge, TN 37831, United States

Quantifying net carbon (C) storage by forests is a necessary step in the validation of C sequestration estimates and in assessing the possible role of these ecosystems in offsetting fossil fuel emissions. In eastern North America, five sites were established in deciduous forests to provide measurements of net ecosystem CO_2 exchange using micro-meteorological methods (NEE), and measures of major C pools and fluxes, using a combination of forest mensurational, eco-physiological, and other biometric methods. The five study sites, part of the AmeriFlux network, ranged across 10° of latitude and 18° of longitude, but were all of similar age, canopy height, and stand basal area. Here we present a cross-site synthesis of C storage estimates, comparing meteorological and biometric approaches, and also comparing biometric estimates based on analyses of autotrophic C pools and heterotrophic C fluxes (net ecosystem production, NEP) versus those based on measurements of change in two major C pools (ΔC). Annual above-ground net primary production varied nearly two-fold among sites and was strongly correlated with average annual temperature and with annual soil nitrogen mineralization (N_{min}). Estimates of NEP ranged from a low of 0.3 Mg C ha^{-1} yr^{-1} in northern Michigan to a high of 3.5 Mg C ha^{-1} yr^{-1} in central Indiana, and were also well correlated with N_{min}. There was less variation among sites in estimates of ΔC (range, 1.8 3.2 Mg C ha^{-1} yr^{-1}). In general, ΔC more closely matched NEE than did NEP, but there was no systematic pattern among sites in over- versus under-estimation of the biometric compared to the meteorologically based measures. Root and soil C dynamics were significant sources of uncertainty in our biometric measures and represent a prerequisite area of study needed for accurate estimates of forest C storage.

B42D-04 1415h

Controls over Carbon Fluxes in a High Elevation Subalpine Forest

Russell K Monson[1,2] (303-492-6319; Russell.Monson@colorado.edu); Andrew A Turnipseed[1] (aturnip@colorado.edu); Jed P Sparks[1] (Jed.Sparks@colorado.edu); Peter C Harley[3] (harley@ucar.edu); Laura E Scott-Denton[1] (Laura.Scott@colorado.edu); Kimberly Sparks[1] (Jed.Sparks@colorado.edu); Travis E Huxman[1] (Travis.Huxman@colorado.edu)

[1]Department of EPO Biology, University of Colorado, Boulder, CO 80309, United States

[2]Cooperative Institute for Research in Environmental Science, University of Colorado, Boulder, CO 80309, United States

[3]Atmospheric Chemistry Division, National Center for Atmospheric Research, Boulder, CO 80301, United States

We studied net ecosystem CO_2 exchange (NEE) dynamics in a high-elevation, subalpine forest in Colorado, USA, over a two-year period. Fundamental features of forest structure and turbulence are reported, including an estimated leaf area index of 4.2 m^2 m^{-2}, canopy gap fraction of 17%, canopy height of 11 m, displacement height of 7.6 m, and roughness length of 1.79 m. Assuming similarity to sensible heat flux, summertime turbulent fluxes for CO_2 and H_2O occur at frequencies less than 1 Hz. Annual carbon sequestration for the forest was 81 and 58 g C m^{-2} for each of the two years. Despite its evergreen nature, the forest did not exhibit net CO_2 uptake during the winter, even during periods of favorable weather. The largest fraction of annual carbon sequestration occurred in the early growing-season; during the first 30 days of both years. Reductions in the rate of carbon sequestration after the first 30 days were due to higher ecosystem respiration rates when mid-summer moisture was adequate (as in the first year of the study) or lower midday photosynthesis rates when mid-summer moisture was not adequate (as in the second year of the study). The lower annual rate of carbon sequestration during the second year of the study was due to lower rates of CO_2 uptake during both the first 30 days of the growing season and the mid-summer months. The reduction in CO_2 uptake during the first 30 days of the second year was due to an earlier-than-normal spring warm-up, which caused snow melt during a period when air temperatures were lower and atmospheric vapor pressure deficits were higher. The reduction in CO_2 uptake during the mid-summer of the second year was due to an extended drought, which was accompanied by reduced latent heat exchange and increased sensible heat exchange. Day-to-day variation in the daily-integrated NEE during the summers of both years was high, and was correlated with frequent convective storm clouds and concomitant variation in the photosynthetic photon flux density (PPFD). The results of this study are in contrast to those of other studies that have reported increased annual NEE during years with earlier-than-normal spring warming. In the current study, the lower annual NEE during 2000, the year with the earlier spring warm-up, was due to (1) coupling of the highest seasonal rates of carbon sequestration to the spring climate, rather than the summer climate as in other forest ecosystems that have been studied, and (2) delivery of snow melt to the soil when the spring climate was cooler and the atmosphere drier. Furthermore, the strong influence of mid-summer precipitation on CO_2 uptake rates make it clear that water supplied by the spring snow melt is a seasonally-limited resource, and summer rains are critical for sustaining high rates of annual carbon sequestration.

B42D-05 1430h

Measuring the Effect of Selective Logging on Tropical Forest-Atmosphere Exchange

Scott D Miller[1] (sdmiller@uci.edu); Mike Goulden[1] (mgoulden@uci.edu); Mary Menton[1] (mary@tap.com.br); Marcy Litvak[1] (mlitvak@uci.edu); Michela Figuera[1] (michela@tap.com.br); Cleilim Sousa[1] (albert_bio@hotmail.com); Humberto da Rocha[2] (humbertο@model.iag.usp.br); Helber Freitas[2] (helbercf@model.iag.usp.br); Leandro Della V.O.Pinto[2] (leandro@model.iag.usp.br)

[1]University of California at Irvine, 220 Rowland Hall Dept. of Earth System Science, Irvine, CA 92697-3100, United States

[2]University of Sao Paulo, Rua do Matão, 1226 Departamento de Ciências Atmosfricas, São Paulo, SP 05508-900, Brazil

We are using long-term eddy covariance to directly measure the effects of selective logging on the energy and trace gas exchange of a tropical forest, as a component of the Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA). We began measurements in June 2000 above a primary evergreen stand in the Tapajos National Forest (km 83), Para, Brazil. Logging occurred in September 2001. Approximately 2.5 trees per hectare were cut in the direction east of the tower (the climatological wind direction, or tower footprint). A larger fraction of the canopy was removed during logging due in part to vines that join adjacent crowns. Collaborators at Harvard University are making comparable measurements at a nearby site (km 67) that will not be logged, providing an experimental control for the logged site. The first year of eddy flux measurements suggest considerable net CO2 sequestration, consistent with other eddy flux measurements in Amazonia. However, a closer examination indicates that the turbulent flux at 65 m may substantially underestimate nighttime respiration during low winds and stable stratification. Measurements at both sites are expected to continue for at least three years. We will use our measurements from the three years following the cut to determine how much carbon is lost, when and if the forest resumes carbon accumulation, and how selective logging affects energy and hydrological balance.

B42D-06 1445h

Effects of spatial heterogeneity on sampling errors in CO2 flux measurements over uneven-aged forests

Peter E Levy[1] (44 131 445 8556; plevy@ceh.ac.uk)

Dennis Baldocchi[2] (510 642 2874; baldocchi@nature.berkeley.edu)

[1]Centre for Ecology Hydrology, Bush Estate, Penicuik EH26 0QB, United Kingdom

[2]University of California, Berkeley, Ecosystem Science Division, Department of Environmental Science, Policy and Management, 151 Hilgard Hall, Berkeley, CA 94720, United States

Net ecosystem productivity data from the FluxNet network of eddy covariance flux tower sites are currently being used to infer carbon sequestration by terrestrial vegetation. Long-term measurements from these sites have often found positive values of NEP. When scaled up using simple methods, these measurements imply higher rates of regional-scale carbon sequestration than are calculated by inverse modelling of the atmospheric CO2 concentration. This has raised the question as to whether there are biases inherent in the eddy covariance technique itself, or in the scaling procedures, which complicate the interpretation of the data. It has been suggested that the spatial heterogeneity within uneven-aged forests would cause large systematic sampling errors in tower-based flux measurements. This phenomenon can be quantified in terms of the sensor location bias, the degree to which a flux measured at a given location differs from the aggregated landscape-scale flux. Here, we applied (1) a modelling approach to quantify the sensor location bias in eddy covariance measurements of CO2 fluxes over virtual forests; and (2) an analysis of IKONOS satellite images, to identify the degree of spatial heterogeneity around actual FluxNet tower sites, and the associated sampling error.

B42E MC: 122 Thursday 1520h

Carbon and Nitrogen Interactions in Forest Ecosystems

Presiding: **H Sievering,** Colorado University at Denver**; D Hollinger,** USDA Forest Service

B42E-01 1520h

The Coupled Nature of C and N Cycles in Forest Ecosystems: Evidence, Implications and Uncertainties

Scott V. Ollinger[1] (603-862-1792; scott.ollinger@unh.edu)

John D. Aber[1] (603-862-1792; john.aber@unh.edu)

Herman Sievering[2] (303-556-4277; hsieveri@carbon.cudenver.edu)

[1]University of New Hampshire, Complex Systems Research Center, Morse Hall, Durham, NH 03824, United States

[2]University of Colorado at Denver, Department of Geography, Geology, and Environmental Sciences, Denver, CO 80217, United States

Cycles of carbon and nitrogen in forest ecosystems are mutually and interactively linked through a shared set of biological processes. A large number of field studies across diverse biomes have documented strong and generalizable relationships between foliar nitrogen concentrations and rates of net photosynthesis. This trend reflects the fact that the majority of N in plant canopies is found in the proteins responsible for CO_2 capture (e.g. rubisco). In soils, the accumulation and availability of nitrogen is, in turn, affected by the quality and N content of litter inputs from vegetation. Taken together, these patterns reflect the broadly-coupled nature of terrestrial C and N cycles and suggest that human alteration of any aspect of one cycle can have important implications for the other. Nevertheless, the exact nature of C-N interactions in natural ecosystems can depend on a variety of factors including historical disturbance patterns, the effects of carbon quality on decomposition and N turnover, and the resulting differences in plant-soil feedbacks among species and functional groups. All of these factors greatly complicate efforts to characterize present-day patterns of C and N fluxes across real forested landscapes. Further, human-induced increases in atmospheric CO_2 and N deposition hold the potential for either tightening the linkages between C and N cycles, or causing them to become uncoupled.

This presentation will build on basic concepts to address several broad questions regarding C-N interactions in forests, both as they occur naturally and as they may be affected by elevated CO_2 or N deposition: 1) What evidence is available from the field to demonstrate the coupled nature of C-N cycles in native forest ecosystems? 2) How are C-N interactions in forests influenced by the growth and allocation strategies of different species and/or functional groups? 3) To what degree are current C and N cycles reflected in the chemistry of forest foliage, and 4) Is there evidence to support the notion that that elevated CO_2 or N deposition have altered normal C-N interactions? These questions will be addressed by examining results from several experimental studies with specific focus on a recent field study conducted in the White Mountain region of New Hampshire. That study was aimed at examining relationships between canopy properties, net primary production and soil N dynamics in temperate forest ecosystems and assessing the degree to which these variables can be estimated through remote sensing of canopy chemistry. Results demonstrate relationships between a number of canopy properties and fluxes of C and N, but also highlight interesting differences in natural plant-soil feedbacks among deciduous versus evergreen species.

B

B42E-02 1540h

Interactions of Carbon Gain and Nitrogen Addition in a Temperate Forest

Fakhri A. Bazzaz[1] (617-495-0916; fbazzaz@oeb.harvard.edu)

Sebastian Catovsky (+44 (0)20 7594 2483; s.catovsky@ic.ac.uk)

[1]Harvard University Dept. of Organismic Evolutionary Biology, Biological Laboratories 16 Divinity Ave. , Cambridge, MA 02138, United States

In plants, carbon and nitrogen are intimately related. The plant gains carbon using nitrogen because it is a major constituent of both the light reaction (chlorophyll) and dark reaction (Rubisco and PEP carboxylase). The plant also gains more nitrogen by using carbon to grow roots that can forage for nitrogen, especially the less mobile (NH4+). Rising CO2 and increased nitrogen deposition are important elements of global change, both of which may affect ecosystem structure and function. They may cause a particularly large shift in species composition in systems where contrasting groups of species co-occur, e.g. evergreen coniferous and deciduous broad-leaved tree species. We studied the impact of nitrogen deposition in a mixed forest in central Massachusetts (Harvard Forest). We found that the early-successional broad-leaved species, yellow birch (Betula alleghaniensis) and red maple (Acer rubrum), both showed large increases in biomass, while the late successional species sugar maple (Acer saccharum) and all the coniferous species, hemlock (Tsuga canadensis), red spruce (Picea rubens) and white pine (Pinus strobus), only showed slight increases. As a result, when these species wre grown together, there was a decrease in species diversity. There was a significant correlation between species growth rate and the growth enhancement following nitrogen addition. We used SORTIE, a spatially explicit forest model to speculate about the future of this community. In both hemlock and red oak stands, nitrogen deposition led to shift in forest composition towards further dominance of young forests by yellow birch. We conclude that seedling physiological and demographic responses to increased nitrogen availability will scale up to exaggerate successional dynamics in mixed temperate forests in the future