B41A MCC: 3014 Thursday 0800h

Ecosystems in Flux: Isotopes as Indicators of Ecosystem Change II

(joint with A, H, OS, GC)

Presiding: **J R Brooks,** National Health and Environmental Effects Research Laboratory, U.S. Environmental Protection Agency**; E Sulzman,** Oregon State University

B41A-01 0800h INVITED

Plant DNA: A new substrate for carbon stable isotope analysis and a potential paleoenvironmental indicator

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The δ^{13}C value of fossil plant materials can be used to gain insight into the dominant photosynthetic pathway, as well as other environmental attributes, of ancient plant ecosystems. Nucleotide sequences from land-plant nucleic acids extracted from 400 ka sediments have been recognized as the oldest authenticated fossil DNA, making the inference of plant taxonomy possible in substrates devoid of plant macro- and microfossils. If the C isotope relationship between bulk plant tissue and associated plant nucleic acids were known, fossil plant nucleic acids could be analyzed for δ^{13}C values and used as land-plant isotopic substrates within mixed organic material. Toward this end, we present δ^{13}C analyses of nucleic acids isolated from 12 higher-plant species that span the full phylogenetic diversity of seed plants. Extracted nucleic acids were dominated by double-stranded DNA containing fragments of rbcL gene $\sim$ 350 base pairs in length. The C isotope compositions of plant nucleic acids were found to be enriched in ^{13}C relative to bulk plant tissue by a constant value ($1.39^{o}/_{oo}$). This study represents the first comparison of the δ^{13}C value of nucleic acids to the δ^{13}C value of bulk tissue for multicellular organisms; our results contrasted with the minimal fractionations reported for microorganisms. Because the isotopic enrichment δ^{13}C is constant across tracheophytes, the δ^{13}C value of fossil plant DNA can be used as a paleoenvironmental indicator, eliminating the need for morphological recognition of fossil plant material in paleoenvironmental studies.

B41A-02 0815h

Oxygen, Carbon, and Nitrogen Isotopic Evidence of Environmental Changes in Eastern Lake Erie Over the Past Century

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The oxygen isotopic composition of calcium carbonate that precipitates in hardwater lakes is affected by meteorologic factors whereas the inorganic and organic carbon and nitrogen isotopic compositions lake sediments are influenced by biological productivity within the lake. We have measured the isotopic compositions at 1-cm intervals in three cores of Lake Erie sediment that span the period 1895 to 1991, and we have compared these parameters to meteorological records and to mass accumulation rates of the aquatic productivity proxies, organic carbon and calcium carbonate. Calcite d18O values that become smaller from 1980 to 1991 in the absence of evidence of a summer temperature change suggest a decadal change in air mass trajectories. In contrast, a shift to larger d18O values from 1905 to 1910 that is accompanied by diminished calcite precipitation and higher lake levels suggests a period of cooler summer temperatures. Increases in inorganic and organic d13C values, d15N values, and organic carbon accumulation starting in 1960 reflect the heightened productivity caused by anthropogenic nutrient increases to Lake Erie.

B41A-03 0830h

Parallel δ^{13}C and Conifer Physiognomic Trends Across the Triassic-Jurassic Boundary

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The Triassic-Jurassic mass extinction event ($\sim$200 Ma) had a profound effect on biotic evolution, and herein we describe trends in cheirolepidaceous conifer leaf physiognomy from the Pangean tropics (present northeastern USA) that at least broadly parallel a negative δ^{13}C excursion recorded in the same strata. The physiognomic changes appear at an abrupt (< 10 ky) negative carbon isotope excursion (1) synchronous with a previously described palynological extinction level, fern spike, and Ir anomaly (2), and continue through a prolonged negative excursion, lasting 900 ky (through all three CAMP basaltic extrusive events), encompassing most of the Hettangian age. The physiognomic changes seen in the cheirolepidaceous conifer leafy shoot forms *Brachyphyllum* and *Pagiophyllum* through the δ^{13}C excursions include primarily the development of microphyllous leaves with thickened cuticle and sunken papillate stomata (3). These floral modifications are consistent with intense thermal stress plausibly due to very high atmospheric CO_2 concentrations and corroborate McElwain's (4) thermal damage hypothesis for the Triassic-Jurassic transition that was originally based on different plant taxa from the higher Pangean latitudes in present Greenland and Sweden. Subsequently, a 2- to 5-fold increase in the area of leafy shoots in strata of latest Hettangian age suggest a return to lower thermal stress levels perhaps due to lower CO_2, despite the fact that eastern North America continued to drift into more arid latitudes. The floral physiognomic changes associated with the negative δ^{13}C excursion and likely very elevated CO_2 levels is in many ways a microcosm of the Mesozoic in which the dominance of cheiroleps apparently overlaps with the highest CO_2 levels of the Mesozoic (5). References. (1) Whiteside JH, Olsen PE, Sambrotto RN. 2003. Geol. Soc. Amer. Abst. Prog. (in press). (2) Olsen PE et al., Science 296:1305-1307 (3) Cornet B. 1989. in Olsen PE, Schlische RW, Gore PJW, Internat. Geol. Cong., Guidebooks T351, p. 115. (4) McElwain JC, Beerling, DJ, Woodward FI. 1999. Science 285:1386. (5) Ekart D, Cerling TR, Montanez IP, Tabor NJ. 1999. Am. J. Sci. 299:805.

B41A-04 0845h INVITED

Are Isotope Models of Tree Ring Cellulose Useful for Studies on Ecosystem and Climate Change?

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For many years, the carbon, oxygen and hydrogen stable isotopes of tree ring cellulose have been used to infer environmental change at ecosystem and global scales. Most climate change studies have been based on empirical correlations with measured or inferred meteorological information. Recently, mechanistic models have been developed to interpret and predict the isotopic composition of cellulose. These models help clarify what environmental information might be contained in historic cellulose records. Although it is best to test and parameterize these models under controlled environmental conditions, field-testing is also critical since the tremendous variability of environmental factors in natural habitats could obscure important signals. However, field-testing these models can be problematic due to the large number of parameters that need to be estimated. Two studies will be presented that test a model that predicts the stable oxygen isotope content of cellulose under field conditions. The model adequately accounted for field observations of riparian zone trees at three sites in Arizona, Oregon and Utah that had contrasting isotopic and environmental inputs. Although the cellulose model underestimated the oxygen isotopic content of tree ring cellulose in a study along a transect of decreasing water status in Oregon, it did predict the greatly reduced range in oxygen isotope content over the transect. Both studies show that ambient humidity plays an important role in modifying the primary signal of meteoric water isotopic content in organic matter. Thus, tree ring records could provide important proxy information regarding changes in ecosystem humidity. However, teasing out humidity information may not be trivial due to the number of other factors involved. The use of dual isotope records (carbon and oxygen) allow for better interpretation of environmental information since each isotope provides different, though related, information regarding ecosystem water status. In conclusion, although cellulose models are extremely useful for understanding what signals are potentially present in proxy data, correlating climate data with isotopic data may still be important in order to make inferences regarding ecosystem or global change from ancient tree ring records.

B41A-05 0900h

Free Air Respiratory Carbon Isotope Enrichment Experiment

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Recycling of respiratory carbon in canopies is difficult to measure. Other than a steady state model, there are currently no direct methods of measuring recycling. Respiratory carbon recycling not only will affect the carbon isotope ratio signature of the canopy, but is also important in partitioning gross photosynthesis and respiration from net ecosystem exchange (NEE). In order to better understand recycling, we empirically derived an integrated measure of recycling in a cover crop (*Crotalaria juncea* L.) and compared it with that derived by the steady state model. A measured dose of nitrogen gas having CO_2 with a high Carbon-13 abundance (41%) was applied at ground level ($\sim$10 cm above the soil surface) with a system of hoses in a 10 by 10 m plot embedded in a 30 by 30 m plot. We adjusted the flux rate of this enriched gas weekly to correspond to weekly measurements of soil respiration rates. The gas application rates at ground level were sufficiently low so as to not affect the carbon dynamics of the treatment plot relative to that of a control plot with only nitrogen (no CO_2) applied. The isotopic composition of the applied gas, however, was high enough to significantly increase the isotopic composition of respired CO_2. Using the carbon isotopic composition of respiration and biomass from the control and treatment plots and mass balance principles we calculated that 45% of the total respired CO_2 is recycled by this crop, which compares well with that derived by the steady state model (48%). Partitioning of gross photosynthesis and respiration by isotopic methods usually assumes no recycling. Recycling, however, will have an effect on the isotopic composition of respired CO_2. After correcting for the recycling effects on the carbon isotope ratios of respired CO_2 leaving the canopy, we calculated that the average gross photosynthesis for this crop was 40.4μmoles/m^{2}s and gross respiration was in the order of 17.8 μmoles/m^{2}s. These values are similar to those previously observed in agricultural crops.

B41A-06 0915h

Seasonal Variation in the Carbon Isotope Ratio of Ecosystem Respiration in Two Coniferous Forests

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We examined weekly variation in the stable carbon isotope signature of ecosystem respiration ($\delta^{13}C_R$) using the Keeling plot approach at two forests in Oregon USA: a wet (>2300 mm annual precipitation) 20-year-old *Pseudotsuga menziesii* plantation located in the Coast Range near the Pacific Ocean, and a dry (~520 mm annual precipitation) 250-year-old *Pinus ponderosa* forest located on the eastern slope of the Cascade Mountains. The two forests experience similar regional weather patterns with wet winters and dry summers, but the coastal site has milder temperatures and greater soil and atmospheric water content. Air was sampled on 51 and 42 separate nights at the *Pinus* and *Pseudotsuga* forests, respectively, between 2001 and 2002. Both forests exhibited greater intra-annual variation in $\delta^{13}C_R$ than has been previously observed in C3 ecosystems (>8.0 $^o/_{oo}$ over the year). Mean annual $\delta^{13}C_R$ matched that expected based on annual precipitation, averaging -25.4 $^o/_{oo}$ at the *Pinus* forest and -26.2 $^o/_{oo}$ at the *Pseudotsuga* forest. Variability in $\delta^{13}C_R$ at both sites was highest during seasons when rainfall was abundant (autumn, winter and spring) and lowest during summer drought. During the period of drought, soil temperature was positively correlated with $\delta^{13}C_R$ at both forests. When all seasons were analyzed, $\delta^{13}C_R$ was negatively correlated with soil water content at both forests. The *Pseudotsuga* forest was more strongly coupled to soil and atmospheric water content than the *Pinus* forest. This difference could be related to availability of a deep water source at the *Pinus* forest that buffers it from drought effects. $\delta^{13}C_R$ at the *Pinus* forest was significantly but weakly related to canopy conductance suggesting that $\delta^{13}C_R$ is coupled to canopy gas exchange. $\delta^{13}C_R$ was significantly correlated between the two forests after removal of outliers associated with extreme, site-specific meteorological events (i.e. local freezes), demonstrating that $\delta^{13}C_R$ is coupled across forests located >100 km apart. This coupling is presumably due to shared regional climate.

B41A-07 0930h

Land-use change effects on fluxes and isotopic composition of CO_2 and CH_4 in Panama, and possible insights into the atmospheric H_2 cycle

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Land-use changes in tropical regions are believed to release a quantity of C to the atmosphere which is similar in magnitude to the entire "missing" sink for anthropogenic CO_2. Our research attempts to evaluate carbon cycling in three land-cover systems in central Panama: cow pasture, native tree plantation, and undisturbed moist forest. In this ongoing project, we are collecting samples of air from profiles in the stable, nocturnal boundary layer, which is dominated by ecosystem respiration. Samples are analyzed for CO_2 and its isotopes, CH_4 and its C isotopic composition, N_2O, H_2, CO, and SF_6. We use a flux-gradient method to estimate ecosystem-scale fluxes of trace gases from soil to the atmosphere. Keeling plot intercepts reflect the respiratory contribution of C3 and C4 biomass under contrasting land cover systems, and how this varies with pronounced wet-dry seasonal cycles. C isotopes of methane and gradients of molecular hydrogen provide insight into the source of methane production from pasture and plantation soils. Rainforest soils, in contrast, are sinks for both atmospheric methane and hydrogen. The process oriented nature of this field experiment will contribute to parameterization of carbon cycle models at a variety of spatial scales.

URL: http://ww2.mcgill.ca/biology/faculty/potvin/sardinilla.htm

B41A-08 0945h

Can We Monitor Ecosystem Function Using Keeling Plot Analyses of Nocturnal Cold-Air Drainage?

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The carbon isotope signature of ecosystem respiration, $\delta^{13}C_R$, as measured by the Keeling Plot approach, has been related to short-term variations in weather and ecosystem function in several recent studies. In order to obtain an adequate range of [CO_2] and to sample a consistent vegetation type, investigators typically select sampling locations in relatively flat terrain and uniform canopy cover, but these are unusual conditions for many forested ecosystems. In a pilot study, we are collecting samples for Keeling Plot analyses in cold-air drainage systems in small (60-100 ha), deeply-incised watersheds, one covered with old-growth (ca 450-years-old) Douglas-fir/hemlock forest and one covered with young (ca 45-years-old) Douglas-fir forest. We found that the nightly range of [CO_2] was typically 380-460 ppm, sufficient to develop good estimates of $\delta^{13}C_R$. At any point in time there was little variation in [CO_2] with height through the canopy (0.5-30m), so the required range was obtained by sampling over several hours. There was no indication that samples taken from different heights or at different times of night represented sources with different isotopic signatures. The isotopic signature of respired CO_2 in the older watershed averaged about 1 per mil greater than that of the young watershed, and $\delta^{13}C_R$ of both locations correlated with modeled stomatal conductance 6 days prior to flask sampling.

B41B MCC: Level 2 Thursday 0830h

Very High Resolution Land Cover Mapping Applications to Resource Management Posters *(joint with H, GC, PA)*

Presiding: **S J Goetz,** Woods Hole Research Center**; T Stone,** Woods Hole Research Center

B41B-0876 0830h INVITED POSTER

Stream Health Linkages with High Resolution Land Cover and Landscape Configuration Metrics

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The amount of impervious surface area (ISA, e.g. roads, parking lots, buildings) within a watershed has long been known to impact the quality of nearby streams and waterways, as measured by their chemical and biotic composition. Vegetation in riparian zones can reduce the negative impacts of ISA by buffering runoff and reducing flow velocities that incise stream channels. Methods to map impervious areas and stream buffers are therefore of great interest to a broad community of natural resource managers. Traditionally, stream buffers and ISA were mapped using visually interpreted aerial photographs and, for example, assigning coefficients to land use categories - a type of "classify and multiply" approach. We have developed methods, using decision tree algorithms, to map these critical landscape variables using high resolution satellite imagery (4m Ikonos). Our approach provides highly accurate maps of impervious surfaces and tree cover. We report on analyses of the links between these maps and stream health for 246 small watersheds within a 1300 km2 area of the mid-Atlantic region - an area of highly altered land cover and rapid land use change. Impervious surface area was found to be the primary predictor of stream health, followed by tree cover in riparian buffers, and total tree cover within entire watersheds. A number of issues associated with mapping using Ikonos imagery were encountered, including differences in phenological and atmospheric conditions, shadowing within canopies and between scene elements, and limited spectral discrimination of cover types. We report on both the capabilities and limitations of Ikonos imagery for these applications, and considerations for extending these analyses to other areas.

B41B-0877 0830h POSTER

High Resolution Mapping of the Impermeable Surfaces of Barnstable County, Cape Cod and their Relationship to Water Quality

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We have developed several impermeable surface maps for all Cape Cod (Barnstable County) to help assess the contribution of paved and other impermeable surfaces to declines in local and regional water quality. These maps have been assembled with the cooperation of many town planning departments, the Cape Cod National Seashore, Mass Military Reservation, the Cape Cod Commission, the Association to Preserve Cape Cod (APCC) and from IKONOS data. The map are being used to predict where new impermeable surface will occur, define current and future hotspots of non-point pollution, and to map the relationships of impermeable surfaces to the zones of contribution (ZOC) of municipal wells. The maps are also used to define the percentage of impermeable surfaces in buffer zones around ponds and estuaries. Combining these data with census data on housing and population density allows us to define the importance of impervious surface as minor or major factors in water pollution.

B41B-0878 0830h POSTER

Hyperspectral Forest Fuel Assessment in the South Platte, Colorado

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There is strong evidence that many current forests are denser and more vulnerable to catastrophic fires than they were historically. In 2002 fire season approximately 3,000 structures were damaged or destroyed in nearly 67,000 forest fires that burned nearly 2.67 million ha in the U.S. Those fires emphasized their importance in the urban/wildland interface and their dramatic effects on ecosystem carbon storage. Therefore it is important to assess regional fire probability in order to appropriately minimize these risks with fuel treatments. Fire risk is controlled by a series of factors, and among which, fuel loading is a critical one that could be managed through fuel removal. Fuel loading describes the characteristics and quantities of biomass, which can be broken down in to several size-classes, normally by vegetation types and forest canopy cover levels. Fuel loading is widely mapped using aerial photos and multi-band satellite images, with intense field sampling. However, the Airborne Visible and Infrared Imaging Spectrometer (AVIRIS) data, with detailed spectral signatures on plant features such as liquid water thickness, vegetation greenness and cellulose contents provide great potential for separating dominant vegetation, live/dead material and canopy cover based on the variations in plant chemicals. In this study we used high altitude AVIRIS data and field spectral measurements to separate fuel loading classes using various hyperspectral unmixing techniques in the Upper South Platte, Colorado. First, we performed minimum noise fraction (MNF) transformation and pixel purity index (PPI) analysis to pickup endmembers with pure spectral signatures. Then, we examined the resulting classes with their key spectral features, and compared them with field spectral measurements. Finally we classified fuel loading in the area into 17 categories, which include 5 canopy cover levels for Ponderosa pine and Douglas-fir. It was indicated in our AVIRIS derived fuel loading map that 13.2% of the study area is over 60% canopy cover with high fuel loading. We validated our remote sensing analysis in an USFS fuel treatment area. It was shown that AVIRIS derived liquid water thickness and vegetation index were strongly related to green leaf biomass and canopy cover respectively in conifer stands, while cellulose content reflected total carbon (live or dead) stored in vegetation.