B21A-0720 0830h POSTER

How Has Urbanization Altered the Carbon Cycle in the United States?

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We use data from two satellites and a terrestrial carbon model to quantify the impact of urbanization on net primary productivity (NPP) and its consequences on carbon balance and food production. Our results show that urbanization is taking place on the most fertile lands and hence has a disproportionately large overall negative impact on NPP. Urban land transformation in the US has reduced the annual NPP by 0.04 Pg C or 1.6 percent of its pre-urban value. The reduction is enough to offset the 1.8 percent gain made by the conversion of land to agricultural use, a striking fact given that urbanization covers an area less than 3percent of the land surface in the US while agricultural lands approach 29 percent of the total land area. At local and regional scales, urbanization increases NPP in resource-limited regions, and through localized warming urban heat contributes to the extension of the growing season in cold regions. In terms of biologically available energy, the loss of NPP due to urbanization of agricultural lands alone is equal to the caloric requirement of 16.5 million people, or about 6 percent of the US population annually.

B21A-0721 0830h POSTER

Assessment of the Impact of Urban Sprawl on Net Primary Productivity

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While urban areas are generally thought to reduce the photosynthetic capacity of the land, little research has been devoted to quantifying the net effect of urbanization on net primary productivity (NPP). The southeastern United States has undergone one of the highest rates of landscape change and urban sprawl in the country, representing an ideal study area in which to develop a remote sensing based methodology for a regional assessment of the impact or urbanization on ecosystem productivity. We used a combination of MODIS and nighttime Defense Meteorological Satellite Program / Operational Linescan System (DMSP/OLS) data to estimate the extent of recent urban sprawl and its impact on regional NPP in the southeastern United States. The analysis based on the nighttime data indicated that in 1992/93 urban areas amount to 4.5 % of the total surface in the region. In the year 2000, the nighttime data revealed an increase in urban developed land by 1.9 %. Estimates derived from the MODIS data indicated that land cover changes due to urban development that took place during the analyzed period reduced annual NPP of the southeastern United States by 0.4 %. Results from this study indicated that the combination of MODIS products such as NPP with nighttime data could provide rapid assessment of urban land cover changes and their impact on ecosystem productivity.

B21B MCC: Hall C Tuesday 0830h

Coupled Behavior of Biotic Systems and Climate I Posters *(joint with GC)*

Presiding: **R Craig,** National Science Foundation**; B A Maurer,** Michigan State University**; E Hadly,** Stanford University

B21B-0722 0830h POSTER

Impact of land-use and climate change on vernal pools in the Central Valley ecoregion of California

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Ecological systems are sensitive to the spatial and temporal distribution of environmental variability. They respond to changes in variability with changes in population processes, species interactions, and, ultimately, species persistence. The distribution of environmental conditions available to species across a region is a function of interactions between ecological tolerances and the spatial and temporal distribution of climate and habitat. This study explored the impact of interactions between changes in the geographic distribution of habitat and climate for rain-fed ephemeral depressional wetlands (vernal pools) in the Central Valley of California. The study used simulation modeling to (1) evaluate hydrologic regimes under historic climates, (2) modify hydrologic regimes based on regional climate predictions, and (3) evaluate land-use and climate change interactions. A stochastic weather generator was used to create synthetic historical time series and downscale predicted changes in regional climate for cool and dry and warm and wet conditions. Modeling results suggest that vernal pool hydrologic regimes exhibit non-linear changes over geographic space and reflect more intense changes in ecologically-relevant conditions than might be suggested by the gradient in precipitation alone. Consideration of climate change impacts in the absence of land-use change (i.e., habitat loss) indicates that vernal pools could experience either a small reduction in annual hydroperiod (cool and dry condition) or, more likely, a significant increase in the annual duration of flooding (warm and wet conditions). However, these region-wide responses change significantly when potential land-use change and associated habitat loss are considered. A bias in the distribution of reserve lands toward drier areas in the Central Valley results in a net shift toward drier, shorter-lasting, and less predictable vernal pools even under wetter climatic conditions. This research demonstrates that interactions between land-use and climate change can result in significant differences in the magnitude and direction of impacts compared to those predicted for either variable alone.

B21B-0723 0830h POSTER

Interactive canopies with Nitrogen controls in the new NCAR land model

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The Community Land Model (CLM) is a component of the Community Climate System model (CCSM). Because the water, energy and momentum exchange between the terrestrial ecosystem and the atmosphere are closely related to the plant-atmosphere CO2 exchange and the vegetation physiological situations, it's necessary to include the physiological response of terrestrial vegetation to the climate variation. This poster shows the incorporation of an interactive canopy model in the new land model, CLM2, as derived from an earlier one in BATS. The nitrogen controls on evaportranspiration proposed by Dickinson et al. in 2001 are also included. The leaf stomatal resistance is switched to the scheme in BATS to be consistent with its physiological parameters. Newly introduced parameters are evaluated for the Plant Function Type composition in the CLM2. The simulated energy fluxes are compared with the simulation of the CLM2; and the simulated ecophysiological fluxes and state variables are listed and some of them are compared with values from other sources.

B21B-0724 0830h POSTER

Impact of Deforestation on Cloud Properties and Rainfall Over the Costa Rica-Nicaraguan region

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The Nicaraguan-Costa Rican region in Central America exhibits the typical pattern of complex deforestation now seen throughout the tropics. The region is a mixture of lowland, mostly converted to agriculture, and mountainous regions, where pristine forests still persist. At present the northern fertile plains of Costa Rica are mostly utilized for agriculture. However in the adjacent regions of southern Nicaragua lowland forests are relatively intact. The extensive agricultural areas of northern Costa Rica is a region of discontinuity in the proposed Mesoamerican Biological Corridor which would connect the montane forests in Costa Rica to the lowland forests in Nicaragua.

The present study is part of a larger study which investigates the effects of continuing lowland deforestation and associated regional climate change in Central America on the stability of the entire proposed Mesoamerican Biological Corridor. The present work focuses on the effects of land use on the formation of cloudiness, cloud properties and rainfall in the forested regions of southern Nicaragua and the deforested regions of northern Costa Rica.

Land surface and cloud properties are retrieved using the Moderate Resolution Imaging Spectroradiometer (MODIS) and the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) satellite data and products. The land surface properties retrieved are land surface temperature, albedo, Normalized Difference Vegetation Index (NDVI), Available Soil Moisture fraction and surface energy fluxes. The cloud properties retrieved are cloud optical thickness and effective radii. In addition, the frequency of cumulus cloudiness on hourly basis are derived from the Geostationary Operational Environmental Satellite (GOES) and rainfall is studied using Tropical Rainfall Measuring Mission (TRMM) satellite products. The correlations between the surface properties, cloud properties, cumulus cloudiness and rainfall as a function of ecosystem and topography is examined. Previous modeling work has shown that in this region the lowlands and highlands are highly coupled. Preliminary results from numerical modeling studies illustrating the impacts of deforestation on the regional climate will also be presented.

B21B-0725 0830h POSTER

Impact of Land Use on Cloud Properties Over the Haiti/Dominican Republic

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The focus of this study is the effect of land use characteristics and surface properties on the preferential formation of cloudiness, especially cumulus cloudiness over Haiti and Dominican Republic for the year 2001. A combination of satellite imagery and numerical modeling is used in this study.

Satellite data and products from the Moderate Resolution Imaging Spectroradiometer (MODIS) satellite are used to retrieve surface properties such as land surface temperature, albedo, and Normalized Difference Vegetation Index (NDVI). The satellite data is then used to retrieve available soil moisture fraction and surface energy fluxes using the Soil Vegetation Atmospheric Transfer (SVAT) model. Cloud properties such as cloud optical thickness and effective radii are also retrieved over this region. In addition, the frequency of cumulus cloudiness on hourly basis is derived from

Geostationary Observational Environmental Satellite (GOES). Rainfall over this region is examined using Tropical Rainfall Measuring Mission (TRMM) satellite products.

Correlations between the various surface characteristics, cloud properties, cumulus cloudiness and rainfall are examined as a function of ecosystem and topography in this region. Finally, the Colorado State University (CSU) Regional Atmospheric Modeling System (RAMS) is applied to selected regions of Haiti and Dominican Republic to simulate the rainfall and cloudiness patterns and to understand the interactions between the land use, cloudiness, cloud properties and rainfall.

B21B-0726 0830h POSTER

Land Surface Phenology in Kazakhstan: Climatic Variability and Institutional Change

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Kazakhstan is the second largest country to emerge from the collapse of the Soviet Union. At 2.7 million sq km, Kazakhstan is nearly four times the size of Texas and more than one-third the size of the conterminous US. Kazakhstan is mostly rangeland: nearly 70% of the land area is grazed by cattle, sheep, goats, and other livestock. Consequent to the abrupt institutional changes surrounding the disintegration of the Soviet Union in the early 1990s, the Kazakhstan region has reportedly undergone extensive land-cover change. However, observing and quantifying these changes is difficult because of (1) the loss of regional environmental monitoring networks at the beginning of the 1990s and (2) the lack of historical Landsat imagery over much of the region, due to gaps in ground station reception masks.

Were the institutional changes sufficiently great to affect NDVI phenology at spatial resolutions and extents relevant to mesoscale meteorological models? To explore this question, we used the NDVI time series from the Pathfinder AVHRR Land (PAL) data set, which consists of 10 d maximum NDVI composites at a spatial resolution of 8 km. Daily minimum and maximum temperatures, and daily precipitation rates were extracted from the NCEP/NCAR CDAS/Reanalysis Project. We produced 10 d composites of growing degree-days (GDD) and precipitation amounts. Simple quadratic models were used to relate NDVI time series to GDD. Two agricultural areas were examined: the region of rain-fed spring wheat cultivation in the north (25600 sq km near Kostanai) and the region of irrigated cotton and rice in the south (576 sq km near Kyzylorda). Two periods were evaluated: during the Soviet era (1985-89) and after the independence of Kazakhstan (1995-99).

Models for the irrigated area had a better fit than the models for the rain-fed area, but all models were strongly significant. In the north, the temperature regime and the mean precipitation amounts were comparable for 1985-89 and 1995-99. The models displayed similar timing and magnitude for NDVI. The southern irrigated area displayed different temporal developments and magnitudes of NDVI between 1985-89 and 1995-99; the second period displays higher peak NDVI. The temperature regime and the accumulation of GDD were similar in both periods. Although the imputed precipitation was significantly different, it is not likely to be responsible for the observed differences in NDVI, due to the low magnitude of precipitation relative to the crop water demands. Thus, we conclude that the climatic conditions between the two periods are not effectively different and, further, that the observed differences in the temporal development of NDVI result from changes in agricultural practices.

URL: http://www.calmit.unl.edu/kz/

B21B-0727 0830h POSTER

Modeling Fall Run Chinook Salmon Populations in the San Joaquin River Basin Using an Artificial Neural Network

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The number of chinook salmon returning to spawn during the fall run (September-November) were separately modeled for three San Joaquin River tributariesthe Stanislaus, Tuolumne, and Merced Riversto determine the sensitivity of salmon populations to hydrologic alterations associated with potential climate change. The modeling was accomplished using a feedforward artificial neural network (ANN) with error backpropagation. Inputs to the ANN included modeled monthly river temperature and streamflow data for each tributary, and were lagged multiple years to include the effects of antecedent environmental conditions upon populations of salmon throughout their life histories. Temperature and streamflow conditions at downstream locations in each tributary were computed using the California Dept. of Water Resources DSM-2 model. Inputs to the DSM-2 model originated from regional climate modeling under a CO2 doubling scenario. Annual population data for adult chinook salmon (1951-present) were provided by the California Dept. of Fish and Game, and were used for supervised training of the ANN. It was determined that Stanislaus, Tuolumne and Merced River chinook runs could be impacted by alterations to the hydroclimatology of the San Joaquin basin.

B21B-0728 0830h POSTER

Temperature Acclimation of Terrestrial Ecosystem Respiration and Implications for Global Climate-Carbon Cycle Feedbacks

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Simulations with general circulation models that include an interactive global carbon cycle indicate a positive feedback between climate change and atmospheric CO_2 concentration. Both future climate change and CO_2 concentrations are higher in the coupled climate-carbon cycle simulations than in simulations without the coupling. Most of the increase in CO_2 concentration can be attributed to terrestrial biospheric response to changes in climate, with increases in ecosystem respiration in response to increasing temperature being a major factor. However, these simulations do not allow for ecosystem acclimation to warmer temperatures. Field and laboratory observations show that plants and microbial communities often respond (i.e., acclimate) to elevated temperatures with a decline in the rate at which respiration increases with temperature. For the same change in temperature, respiration with acclimation is lower than respiration without acclimation. Thus temperature acclimation of ecosystem respiration will tend to reduce the magnitude of the climate-carbon cycle feedback. We are investigating the implications of temperature acclimation on climate-carbon cycle feedbacks in coupled climate-carbon models. We identified alternative temperature acclimation responses for both autotrophic (plant) and heterotrophic (microbial) respiration that are supported by empirical evidence, and we implemented these responses in a local-scale model of ecosystem carbon dynamics (LoTEC) and in a global model of terrestrial ecosystem carbon (GTEC). We present simulations of CO_2 released in ecosystem respiration at both scales in response to future climate change scenarios. Our results raise significant scientific questions about the rates at which acclimation occurs, but they also indicate that the next generation of coupled climate-carbon models should include robust representations of temperature acclimation by the terrestrial biosphere.

B21B-0729 0830h POSTER

A dynamical global vegetation model for studies of the coupled atmosphere-biosphere system

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We present a new dynamical global vegetation model principally designed to be included in atmospheric general circulation models (AGCMs) or regional climate models. The model consists of a surface-vegetation-atmosphere transfer scheme coupled to a dynamical global vegetation model. It therefore simulates the principal processes of the continental biosphere influencing the global carbon cycle (photosynthesis, autotrophic and heterotrophic respiration of plants and in soils, fire, . . .) as well as latent, sensible and kinetic energy exchanges at the surface of soils and plants. As a dynamical vegetation model, it explicitly represents competitional processes such as light competition, gaps, establishment, etc. It can thus be used in transient simulations of climate change, but it can also be used with a prescribed vegetation distribution. The whole seasonal phenological cycle is calculated prognostically without any prescribed dates or use of satellite data. The model is designed for an easy use as biosphere module in an AGCM, and first simulations with this model coupled to the LMDz atmospheric general circulation model are under way.

This coupled hydrological-vegetation model is validated in stand-alone experiments against local observations of, for example, vegetation types, carbon stocks and fluxes. Simulated vegetation distribution and leaf area index in a global simulation is evaluated against observations.

B21B-0730 0830h POSTER

Using Linear and Non-Linear Methods to Study Precipitation-Vegetation Dynamics at Global Scales

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Large areas of the Earth's land surface experience significant spatio-temporal variability in precipitation regimes. This variability can result in important perturbations to ecosystem processes. In recent years remote sensing observations have been used to examine large-scale dynamics in ecosystem response to climate. However, because of the complexity of both the processes and data sets involved, analysis of coupled spatio-temporal variability in remote sensing and other earth science data poses a challenging problem. In this paper, linear and non-linear statistical learning techniques are used to perform automated feature extraction and unsupervised data analysis of precipitation and remotely sensed vegetation index data sets at global and inter-annual scales. To examine the joint variability of precipitation and vegetation, canonical correlation analysis (CCA) and maximum covariance analysis (MCA) are used. These techniques are designed to isolate coupled modes of different variables in both space and time. Unfortunately, MCA and CCA require fairly strict assumptions concerning the statistical distribution of the input variables. When such assumptions are not met, non-linear techniques can provide additional information that cannot be retrieved using linear techniques. In particular, independent component analysis (ICA) has recently emerged as a novel technique to isolate non-Gaussian signals from multivariate data. While many linear techniques rely on the variance/covariance information contained in a dataset, ICA uses higher order statistical moments to isolate patterns. ICA is particularly powerful for identifying spatial and temporal artifacts that are commonly contained in Earth science data sets and for isolating anomalous events that arise from perturbations in the atmosphere-biosphere system such as droughts and floods associated with El-Niño (and other) events. In this paper, ICA is used to extract information related to the spatial and temporal variability of atmospheric and terrestrial data that is complementary to results from CCA and MCA. Specifically, we apply ICA and CCA to time series of precipitation and normalized difference vegetation index data sets at continental and global scales. Results reveal interesting space-time patterns that are diagnostic of climate-biosphere interactions.

B21B-0731 0830h POSTER

Past Variations of Methanotrophy and Ecosystem Response Recorded by Molecular Biomarkers

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Variations of size and distribution of the marine sedimentary reservoir of methane in geologic history are increasingly viewed as important for the global carbon cycle. Typically, the evidence for such variations is circumstantial because it is based on stable isotope compositions of calcareous fossils or total organic carbon. We have extended the high-resolution record of distribution and isotopic composition of prokaryotic biomarkers in sediments from the Santa Barbara Basin (SBB), ODP site 893, to two continuous intervals covering the late Pleistocene and early Holocene. The distribution of biomarkers from methanotrophic prokaryotes indicates that concentrations of methane in basin waters have systematically varied in phase with Northern hemispheric climate oscillation. The most plausible source of the methane is sedimentary methane hydrate as proposed earlier [Kennett et al., Science 288, 128-133, 2000]. Previous estimates about rates of methane outgassing will be refined on the basis of molecular data. A complex ecological feedback of surface water communities to conditions prevailing during dissociation of hydrate is indicated by increases in relative abundance and isotopic composition of biomarkers from prokaryotic and eukaryotic algae shortly after or coinciding with the presumed release of methane.

B21B-0732 0830h POSTER

Growing Season Patterns in Eriophorum vaginatum L. Biomass Allocation: the Influence of Experimental Manipulation

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Detailed comprehension of bigeochemical cycling under current and future climate regimes requires a thorough knowledge of root dynamics. With recent improvements in optic and electronic technology, minirhizotron camera systems have become a useful tool for measuring aspects of the belowground dynamic in some natural systems. This study used minirhizotron camera technology during 2001 and 2002 at the Toolik Lake Long Term Ecological Research site in Northern Alaska. Growing season patterns in root production rate and leaf growth rate were examined in the arctic sedge, Eriophorum vaginatum L., under ambient, warmed and fertilized conditions. Experimental results demonstrate a similar response to warming and fertilization. Aboveground, and belowground, plants were physiologically and phenologically plastic in their response. Warmed and fertilized plants exhibited higher leaf growth rates and earlier emergence of the seasons final leaf cohort. Belowground, warmed plants produced roots at a faster rate than plants in control plots, but these high rates were confined to an early- and late-season peak. In fertilized plots, plants responded with just an early season peak in root production rate, but one with rates that exceeded those seen under ambient and warmed conditions. The similarity in warming and fertilization response characteristics may arise independently, or warming and fertilization may act upon the same proximal variable (i.e., plant-available nutrients). Identification of driving variables and the range over which E. vaginatum can capitalize will further our mechanistic understanding of current growing season allocation patterns and facilitate prediction of future species assemblages and interactions.

B21C MCC: 132 Tuesday 0830h

Biogeochemical Cycling of Carbon, Nitrogen, and Heavy Metals: Implications for Ecosystem Restoration and Global Cycles I *(joint with OS)*

Presiding: **J O Sickman,** California Department of Water Resources**; A Mueller-Solger,** California Department of Water Resources

B21C-01 0830h INVITED

The Contribution of Natural and Restored Wetlands to Changes in the Concentration and Composition of Dissolved Organic Material in the Sacramento-San Joaquin Delta and San Francisco Estuary

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The quantity and quality of wetland-derived dissolved organic material (DOM) entering delta and estuary environments remains poorly characterized, even though DOM has two roles of societal significance: 1) it supports estuarine foodwebs, which commonly are a habitat for endangered species, and 2) it presents problems when it occurs in drinking water supplies, because it forms carcinogenic byproducts when treated. The Sacramento-San Joaquin Delta is a source of drinking water for more than 20 million people and contributes 80% of the DOM entering the San Francisco estuary, nearly doubling the concentration of DOM in the influent river water. The majority of the Delta is composed of below-sea-level peat islands that are maintained in agricultural production by continuous pumping of DOM-rich drain water into Delta channels. Previous studies indicate that changes in DOM composition in water passing through the Delta are not consistent with the addition of peat island drain water, and are more consistent with the addition of wetland-derived material. Therefore, wetlands may contribute substantially to DOM export to the estuary. Although wetlands currently constitute only 14% of the Delta, restoration is planned that would more than double this wetland area, potentially altering DOM quality and content in the Delta and estuary waters. During the past several years, the seasonal variation in the quality of DOM added by a variety of wetland types and island drains within the Delta and estuary has been examined. In this study, 13 sites were sampled 5 times. As of September 2002, the samples have been analyzed to determine the content of hydrophobic DOM, characterize the ultraviolet absorbance and fluorescence properties, and quantify the susceptibility to biodegradation before and after photoexposure. Samples were humic-rich, averaging more than 75% hydrophobic content and varying from 74 to 86%, with the variation in hydrophobic content between samples corresponding to changes in the optical properties. Samples typically were refractory with respect to biodegradation, having an average of 11% of the DOM being susceptible to biodegradation prior to photoexposure, but the range was from 1% to 48%. Following photoexposure, samples generally were more refractory rather than more labile. Wetland DOM reacted to form more drinking water disinfection byproducts than influent waters, but some wetland types seemed to contribute fewer precursors. Seasonal variation in biodegradation and chemical parameters was much greater than variation among wetland types, and the peak of biodegradability was not related to the seasonal peak in DOM. Therefore, the addition of DOM through the Delta is controlled by changes in the nature of the source material rather than changes in efficiency or extent of remineralization.

B21C-02 0845h INVITED

Watershed nutrient inputs, phytoplankton accumulation, and C stocks in Chesapeake Bay

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Inputs of N and P to Chesapeake Bay have been enhanced by anthropogenic activities. Fertilizers, urbanization, N emissions, and industrial effluents contribute to point and diffuse sources currently 2-7X higher for P and 5-20X higher for N than those from undisturbed watersheds. Enhanced nutrient inputs cause phytoplankton blooms which obscure visibility, eliminate submerged grasses, and influence the distribution of C within the Bay. Accumulations of dissolved organic and particulate organic C lead to enhanced microbial respiration in isolated bottom waters, and dissolved oxygen is seasonally reduced to trace levels during summer.

Cultural eutrophication is not unique to Chesapeake Bay. Although some estuaries such as the Delaware, Hudson, and San Francisco Bay also have high anthropogenic inputs, these estuaries have much shorter residence times, and much of the N and P may be exported to the coastal ocean. However, in Chesapeake Bay, with residence times > 2 months, internal processing of watershed inputs results in local algal blooms within the estuary.

Watershed restoration strategies for Chesapeake watersheds have had limited success to date. Groundwaters are enriched with nitrate, and the long residence times of groundwaters mean slow responses to watershed improvements. The few successes in the Chesapeake have been associated with point source reductions, although continued human population growth can easily override restoration efforts. Widespread improvement in water quality has yet to occur, but the limited successes show that the Bay responds to load changes.

B21C-03 0900h INVITED

Ecosystem Modulation of Dissolved Carbon Age in a Temperate Marsh-Dominated Estuary

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The concentrations and isotopic values (Δ14C and δ13C) of dissolved inorganic, organic and particulate organic carbon (DIC, DOC, and POC, respectively) were measured in the Parker River watershed and its associated estuary to determine the age of carbon entering the estuary and how estuarine processing affects the quantity and apparent age of carbon transported to the Gulf of Maine. The watershed measurements indicated the transport of Δ14C-enriched modern DIC and DOC and variably aged POC from the watershed to the estuary. Surveys within the watershed aimed at determining which land use type dominated the DOC export indicated that wetlands, although making up 20% of the land use could be responsible for 75% of the DOC export. We therefore conclude that the wetland land uses of the Parker River watershed are exporting mainly D14C-enriched modern DOC. DIC isotopes indicate that the source of DIC in the Parker River watershed is dominated by the weathering of non-carbonate parent material by /Delta14C enriched CO2 originating from the respiration of young organic matter in soils.

Transects in the associated estuary displayed net additions of all carbon species. For DOC and DIC the fluvial export of this internally added DOC and DIC was approximately equal to the amount being exported from the watershed, stressing the importance of focusing on estuaries when estimating the export of carbon to the coastal ocean. With respect to DIC, the total input is even larger when the atmospheric exchange of excess pCO2 is calculated. The /Delta C-DOC and /DeltaC-DIC transects both indicate that the internally added DOC and DIC is /DeltaC-enriched modern material. The source of this material is the associated marshes and estuarine phytoplankton, with the relative