

the large size of Canadian forest area, the high spatial resolution required, and the limitations in the current data availability and quality, carrying out these tasks requires substantial effort. We will present our most updated progress on the conference.

**B12F-11 1640h**

**Carbon Budget Dynamics Change Induced by Artificial Disturbance in Siberian@Taiga Region**

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Boreal forest in eastern Siberia was disturbed artificially to detect the impact of disturbance on carbon budget. The observation tower for heat-water budget and CO<sub>2</sub> budget was established in 1999 and continuous monitoring of budgets were conducted under undisturbed condition. The biomass of the forest before disturbance was also obtained by on-the-spot investigation. Cutting over all standing trees was taken place in 2000 winter season as one of types of disturbance in the rectangle shape with dimension of 150m long and 80 m wide. Cutting down trees were all moved out the site. In some portion of the site, ground surface vegetation was burned as to simulate the fire impact of forest fire to the ground surface. The comparison of Carbon budgets both before and after disturbance indicates that CO<sub>2</sub> flux to the atmosphere measured as 0.2 mol/m<sup>2</sup>day after disturbance. On the other hand, CO<sub>2</sub> flux from atmosphere was obtained as 0.5 mol/m<sup>2</sup>day before disturbance. Soil respiration changes by disturbance was compared with observed values monitored by means of chamber measurements. Ground surface burned reduced the soil respiration by 50

The LCLUC trajectory of a particular landscape under influence by human actions begins with the transition from conditions dominated by natural vegetation to a frontier state. Land use activities in a frontier state are centered primarily around resource extraction and development of infrastructure such as roads or ports. Under the proper conditions (e.g. soils, climate), the frontier state gives way to an agricultural landscape by further conversion of natural vegetation to agriculture and management of cleared land for agriculture. The maximum extent of this conversion is a function of local biophysical and socio-economic factors. For example conversion of arid lands may be limited by water availability, access to capital for development of water resources and access to markets for the products. Given the appropriate conditions (e.g. economic and social policy, generation of wealth), LCLUC evolves as large settlements and industrialization develop in concert with high land prices and agricultural intensification. In some cases (e.g., New England, Appalachia), economic conditions (e.g., better land for agriculture elsewhere) may result in reversion of agriculture to natural vegetation. The last stage in LCLUC is conversion of agriculture to residential and suburban environments (e.g., Baltimore/Washington corridor). Examination of global land cover indicates that every stage is currently present, with areas like the Eastern United States and Western Europe as examples of regions having experienced all stages, while parts of the Amazon basin, Siberia, and Africa are moving through the frontier transition. Whether these frontier regions will evolve along the general LCLUC trajectory will depend on biophysical and socio-economic factors. Some regions like Siberia may never evolve to the agricultural stage and persist as a frontier landscape with its associated impacts. The impacts on biogeochemical and social systems are the most dramatic during transitions between states, with lesser impacts or even recovery during periods of stasis. However, displacement of natural vegetation by anthropogenic land uses currently results in enhanced water yields and higher fluxes of elements such as N and P, which encourage eutrophication of lakes and coastal waters without further land cover change. Social and economic policies are the primary drivers of LCLUC, and regulations are critical for controlling the impacts, especially in the later stages.

**B21A-03 0900h**

**Agricultural land use changes in Amazonia since the mid-1990s: preliminary results of merging agricultural census data with satellite reflectances**

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As part of our research within the Large-scale Biosphere-Atmosphere Experiment in Amazonia (LBA), we are developing a time series of the spatial distribution and abundance of major agricultural activities within the Amazon and Tocantins basins. In previous papers, we have described a new method for integrating land cover classifications from remote sensors with land use information from agricultural censuses. These fused data products, available for the mid-1980s and mid-1990s at five minute (9 km) resolution, have much of the spatial detail of the satellite information and useful attribute detail from censuses; they show snapshots of the density of cropland, natural pasture, and planted pasture across Amazonia in these two periods.

In this presentation we extend, refine, and update the time series in two major ways. Because the initial method for merging land use and land cover information used already-created land cover classifications as input, it was limited by both the classification accuracy and the similarity of land cover classes to the agricultural categories of cropland and pasture. In a sense the products relied, of necessity, on uncertainties in the mapped land cover classes as a basis for the fusion. Additionally, half a decade has passed since the nominal snapshot date of the latest land use map product.

Here we present the preliminary results of merging unclassified raw satellite imagery with agricultural census data. In particular, we explore the ability of weekly NDVI composites from the mid-1990s to identify areas of known land use during the period. By investigating the relationship between density of agricultural area and composite reflectances we expect to train the classifier to identify likely agricultural land use areas within Amazonia. The adopted technique differs from typical classification algorithms that identify pure pixels of desired classes and seek similar characteristics in the image. Instead, the method simultaneously considers the relation between reflectance characteristics and agricultural census values across administrative units, and optimizes the relation between them to produce the classification. Where this relationship is strong, we also present an update of land use patterns for the past year to identify likely land use changes in the region.

URL: <http://sage.meteor.wisc.edu>

**B21A-02 0845h**

**Paleoenvironmental history of a drained tidal freshwater wetland in the Sacramento Delta, California**

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The McCormack-Williamson Tract is a large island situated in the Sacramento Delta, California, USA. This leveed 1,600-acre parcel of land is slated for restoration by The Nature Conservancy, with the goal of reverting the island from intensive agriculture to a historical tidal freshwater wetland and floodplain. To design a suitable restoration strategy, it is necessary to determine the past and present biogeomorphic processes that have operated at the study site using three cores that have been collected from the island. The length of the cores range from about 12-14 m depth and bottom out at a maximum radiocarbon age of 40,100 years before present. The lithostratigraphic facies that are identified in the cores include Holocene floodplain and channel deposits, Scirpus marshes and associated mudflats. Pleistocene glaciofluvial outwash is recorded only in the southern section of island. Pollen and spore analyses reveal that Scirpus marshes occupied the northwest section of the site during the mid-late Holocene. Channels, riparian woodlands, and floodplain habitats occupied the remaining sections of the island throughout the Holocene. Charcoal data indicates that fire was not a significant type of disturbance, whereas the lack of pollen coupled with widespread inorganic sedimentation in many sections of the cores suggests that flooding was a frequent form of disturbance on the island throughout the Holocene. Elemental analysis, coupled with pollen data, clearly show the onset of agriculture as a land-use practice in more recent times. In combination, these data provide base-line studies that are suitable to assist in guiding restoration efforts on the island.

URL: <http://lawr.ucdavis.edu/faculty/gpast/delta.html>

**B21A-04 0915h**

**Coastal Land-Use Dynamics in Southern Sonora, Mexico between 1973-2001**

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Human activities, such as urbanization, agriculture, and shrimp farming are dramatically changing the coastal landscape of southern Sonora, Mexico, and threatening the ecosystems goods and services these natural systems provide. In this study we investigate the trends of human-induced transformations of coastal lands between 1973 and the present. Subscenes from two mosaicked Landsat images from 1973 (MSS), 1986 (MSS), 1992 (MSS), 1994 (TM), 2000 (ETM), 2001 (ETM) were analyzed to evaluate land use and cover changes. We used a combination of supervised and unsupervised maximum likelihood classification to produce thematic land use and land cover maps for change detection and modeling. The results show that the

**B21A MC: 122 Tuesday 0830h**

**Land Use and Land Cover Change: Observations and Consequences I (joint with GC)**

**Presiding:** N Ramunkutty, University of Wisconsin; R Leemans, National Institute for Public Health the Environment (RIVM)

**B21A-01 0830h**

**The Trajectories and Impacts of Land Use and Land Cover Change: A Global Synthesis**

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We have summarized the trajectories of land cover and land use change (LCLUC) and the resulting impacts through a synthesis of results from studies encompassing a wide range of environments. While the specific changes and impacts are in some ways unique to each environment, we have nevertheless identified some general principles that seem to apply across all regions.

most prevalent form of land-use change in the region over the study period has been the transformation of Pithaya forest and coastal wetlands to shrimp aquaculture. Shrimp farms that did not exist in the region in the early 1980s now represent over 12 percent of the study area. Our analysis suggests that this boom in shrimp farming was influenced by a series of policy reforms instituted by the Mexican Government over the last decade intended to open the rural economy to global markets. These reforms include modifications to the Fisheries, Foreign Investment and Land Tenure Laws, changes in the rural credit system, and liberalization of international trade policies (NAFTA). The data indicate overall increased rates of land conversion from natural covers (Pithaya forest, Mesquite forest, Choyal, salt flats) to human dominated ecosystems (aquaculture, agriculture, salt ponds, urban) in the post-reform period (1994 - 2001) compared to the pre-reform period (1973 - 1992). Our results highlight the importance of monitoring local impacts in evaluating national policies.

#### B21A-05 0930h

##### Carbon Dynamics in the Southeastern Plains: A Preceding Study to Quantify the Consequences of Contemporary Land Cover and Land Use Change on Terrestrial Carbon Stocks and Fluxes in Conterminous U.S.

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Coupled with the USGS/EPA study on the spatial and temporal dimensions of contemporary U.S. land cover and land use change (LCLUC), we assess how changes in land cover and land use affect local, regional and national carbon stocks and fluxes in terrestrial ecosystems. A low cost sampling strategy based on Omernik ecoregions is used to localize estimates of the rates of LCLUC and to quantify the corresponding consequences on carbon dynamics. Sampling blocks were randomly selected for each of the 84 ecoregions to identify > 1% change in cover within each ecoregion at an 85% confidence level. The analysis of land cover change is based on five dates of Landsat MSS, TM, and ETM data (nominally 1973, 1980, 1986, 1992, and 2000). Using an ensemble approach, we deploy the CENTURY ecosystem model to simulate carbon dynamics within each of the sampling blocks at the resolution of 60 m by 60 m. The goal is to identify the spatial distribution and temporal change of carbon sources and sinks in the conterminous U.S. and explain the mechanisms that cause the variability. In this paper, our carbon simulation approach is presented with the southeastern plains as a case study.

Part of this work is performed under U.S. Geological Survey contract 1434-CR-97-CN-40274.

#### B21A-06 0945h

##### Land Use Effects on Net Greenhouse Gas Fluxes in the US Great Plains: Historical Trends and Model Projections

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We present maps showing regional patterns of land use change and soil C levels in the US Great Plains during the 20<sup>th</sup> century and time series of net greenhouse gas fluxes associated with different land uses. Net greenhouse gas fluxes were calculated by accounting for soil CO<sub>2</sub> fluxes, the CO<sub>2</sub> equivalents of N<sub>2</sub>O emissions

and CH<sub>4</sub> uptake, and the CO<sub>2</sub> costs of N fertilizer production. Both historical and modern agriculture in this region have been net sources of greenhouse gases. The primary reason for this, prior to 1950, is that agriculture mined soil C and resulted in net CO<sub>2</sub> emissions. When chemical N fertilizer became widely used in the 1950's agricultural soils began to sequester CO<sub>2</sub>-C but these soils were still net greenhouse gas sources if the effects of increased N<sub>2</sub>O emissions and decreased CH<sub>4</sub> uptake are included. The sensitivity of net greenhouse gas fluxes to conventional and alternative land uses was explored using the DAYCENT ecosystem model. Model projections suggest that conversion to no-till, reduction of the fallow period, and use of nitrification inhibitors can significantly decrease net greenhouse gas emissions in dryland and irrigated systems, while maintaining or increasing crop yields.

#### B21A-07 1000h

##### Observational Constraints From Local to Continental Scale on the Analysis of an Integrated Regional Carbon Model

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During the past decade, terrestrial ecologists have been in the search of "the missing carbon sink" which atmospheric scientists have suggested resided in the ecosystems of the northern hemisphere. This search has led to refinements in our basic understanding of carbon cycling and how terrestrial ecosystems modify the changing concentrations of atmospheric CO<sub>2</sub>. The quantification of the changes in carbon fluxes from different terrestrial ecosystem due to climate change and human activities such as deforestation, fire suppression, and agricultural practices at local to regional scales is critical to our understanding of how we are affecting greenhouse gas emissions and how we may reduce the rate of these emissions. Regional analysis of biological control on the terrestrial biospheric processes controlling carbon exchange with the atmosphere and storage of carbon within the ecosystem will greatly enhance our ability to quantify carbon and other greenhouse gas emission from regions within the United States of America and globally. The integrated analysis of land, atmosphere, and human dimension processes provide insight to the factors contributing to the changes in atmospheric CO<sub>2</sub> and the biospheric role in affecting source sink changes on seasonal to inter-annual timeframes. Multiple observations of fluxes, concentrations, and states of C provide constraints on the integrated regional C analysis. Inventory analyses and simulation results indicate that land use has a major impact on the net carbon biome sink of the conterminous US in the range of 0.2 Gt per year. Development of an integrated regional C model includes the processes related to ecosystem development, such as regrowth patterns of forests, plant composition changes, impact of fire, grazing, and cultivation on different ecosystems.

#### B21B MC: 120 Tuesday 0830h

##### Assessing Bioremediation I (joint with H)

**Presiding:** J P McKinley, Pacific Northwest National Laboratory; F S Colwell, Idaho National Engineering and Environmental Laboratory

#### B21B-01 0830h INVITED

##### Principles of Bioremediation Assessment

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Although microorganisms have successfully and spontaneously maintained the biosphere since its inception, industrialized societies now produce undesirable chemical compounds at rates that outpace naturally occurring microbial detoxification processes. This presentation provides an overview of both the complexities of contaminated sites and methodological limitations in environmental microbiology that impede the documentation of biodegradation processes in the field.

An essential step toward attaining reliable bioremediation technologies is the development of criteria which prove that microorganisms in contaminated field sites are truly active in metabolizing contaminants of interest. These criteria, which rely upon genetic, biochemical, physiological, and ecological principles and apply to both in situ and ex situ bioremediation strategies include: (i) internal conservative tracers; (ii) added conservative tracers; (iii) added radioac-

tive tracers; (iv) added isotopic tracers; (v) stable isotopic fractionation patterns; (vi) detection of intermediary metabolites; (vii) replicated field plots; (viii) microbial metabolic adaptation; (ix) molecular biological indicators; (x) gradients of coreactants and/or products; (xi) in situ rates of respiration; (xii) mass balances of contaminants, coreactants, and products; and (xiii) computer modeling that incorporates transport and reactive stoichiometries of electron donors and acceptors. The ideal goal is achieving a quantitative understanding of the geochemistry, hydrogeology, and physiology of complex real-world systems.

#### B21B-02 0845h INVITED

##### Effects of Subsurface Microbial Ecology on Geochemical Evolution of a Crude-Oil Contaminated Aquifer

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We have identified several subsurface habitats for microorganisms in a crude oil contaminated located near Bemidji, Minnesota. These aquifer habitats include: 1) the unsaturated zone contaminated by hydrocarbon vapors, 2) the zones containing separate-phase crude oil, and 3) the aqueous-phase contaminant plume. The surficial glacial outwash aquifer was contaminated when a crude oil pipeline burst in 1979. We analyzed sediment samples from the contaminated aquifer for the most probable numbers of aerobes, iron reducers, fermenters, and three types of methanogens. The microbial data were then related to gas, water, and oil chemistry, sediment extractable iron, and permeability. The microbial populations in the various contaminated subsurface habitats each have special characteristics and thus affect the aquifer and contaminant chemistry.

In the eight-meter-thick, vapor-contaminated vadose zone, a substantial aerobic population has developed that is supported by hydrocarbon vapors and methane. Microbial numbers peak in locations where access to both hydrocarbons and nutrients infiltrating from the surface is maximized. The activity of this population prevents hydrocarbon vapors from reaching the land surface. In the zone where separate-phase crude oil is present, a consortium of methanogens and fermenters dominates the populations both above and below the water table. Moreover, gas concentration data indicate that methane production has been active in the oily zone since at least 1986. Analyses of the extracted separate-phase oil show that substantial degradation of C<sub>15</sub>-C<sub>35</sub> n-alkanes has occurred since 1983, raising the possibility that significant degradation of C<sub>15</sub> and higher n-alkanes has occurred under methanogenic conditions. However, lab and field data suggest that toxic inhibition by crude oil results in fewer acetate-utilizing methanogens within and adjacent to the separate-phase oil. Data from this and other sites indicate that toxic inhibition of acetoclastic methanogenesis in the proximity of separate phase contaminant sources may result in build-up of acetate in contaminant plumes.

Within the aqueous-phase contaminant plume steep vertical hydrocarbon concentration gradients are associated with sharp transitions in the dominant microbial population. In the 20 years since the aquifer became contaminated, sediment iron oxides have been depleted and the dominant physiological type has changed in areas of high contaminant flux from iron reducing to methanogenic. Thus, methanogens are found in high permeability horizons down gradient from the oil while iron reducers persist in low permeability zones. Expansion of the methanogenic zone over time has resulted in a concomitant increase in the aquifer volume contaminated with the highest concentrations of benzene and ethylbenzene.

URL: <http://www.mn.cr.usgs.gov/bemidji/>

#### B21B-03 0900h INVITED

##### In-situ evidence for uranium immobilization and remobilization

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