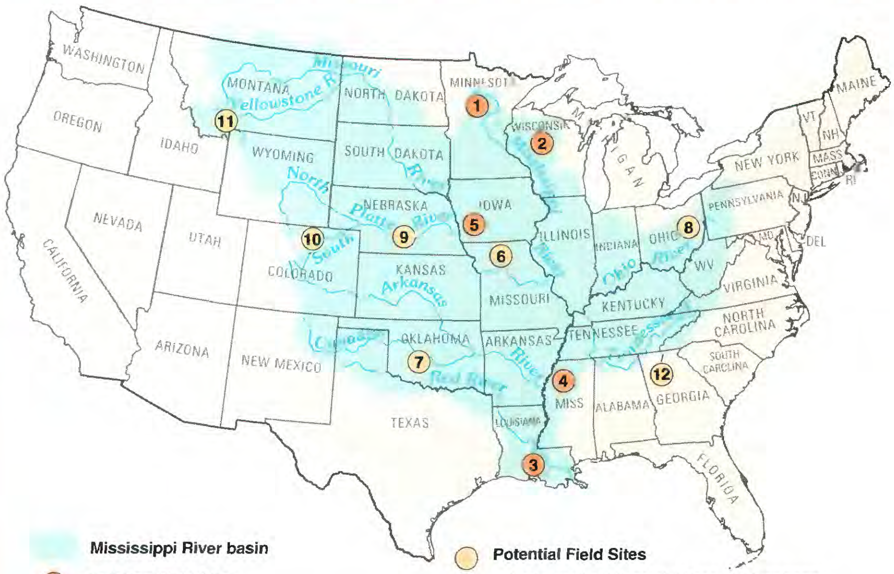
# Can the Global Carbon Budget Be Balanced?

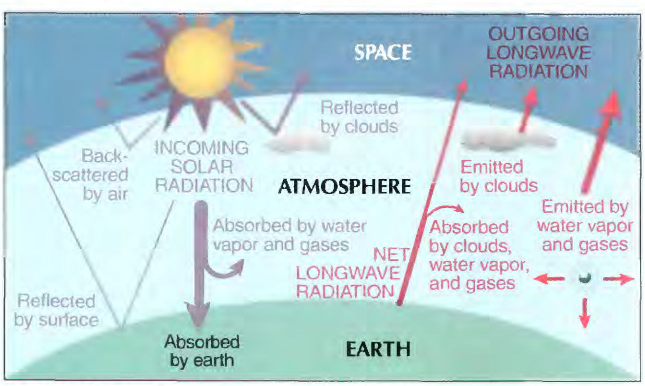
***The Mississippi Basin Carbon Project of the U.S. Geological Survey (USGS) is an effort to examine interactions between the global carbon cycle and human-induced changes to the land surface, such as farming and urbanization. Investigations in the Mississippi River basin will provide the data needed for calculating the global significance of land-use changes on land-based carbon cycling. These data are essential for predicting and mitigating the effects of global environmental change.***



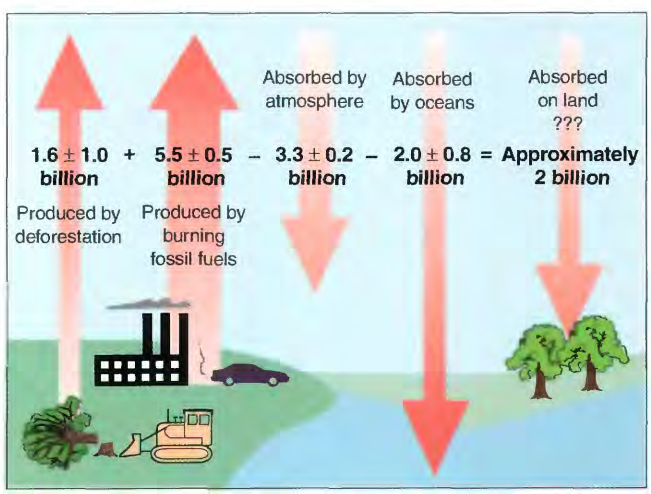

| | Existing Field Sites | | Potential Field Sites |
|---|---|---|---|
| 1 | Minnesota Lakes, Mississippi River basin | 6 | North-central Missouri, Missouri River basin |
| 2 | Wisconsin Lakes, Mississippi River basin | 7 | Little Washita, Oklahoma, Red River basin |
| 3 | Mississippi River Delta, Mississippi/ Atchafalaya River basin | 8 | Coshocton, Ohio, Ohio River basin |
| 4 | Northwest Mississippi, Yazoo River basin | 9 | Big Bend area, Nebraska, Platte River basin |
| 5 | Treynor, Iowa, Nishnabotna River basin | 10 | South Platte, Colorado, Platte River basin |
| | | 11 | Headwaters, Yellowstone/Missouri River basin |
| | | 12 | Upper Tennessee River basin |

***The Mississippi Basin Carbon Project** is focused on the third largest river system in the world. The Mississippi River and its tributaries drain more than 40% of the conterminous United States. The basin includes areas that typify vast regions of the Earth's surface that have undergone human development.*

Scientists who study the global carbon cycle measure and model transfers of carbon. They account for the numerous additions and subtractions that define the distribution of carbon among the oceans, atmosphere, and land. From studies of the geologic record, it is known that the distribution of carbon among these major reservoirs has changed with past changes in climate. Links between the global carbon cycle and the global climate system are complicated, involving atmospheric carbon dioxide ($CO_2$) and the "greenhouse effect." Atmospheric $CO_2$



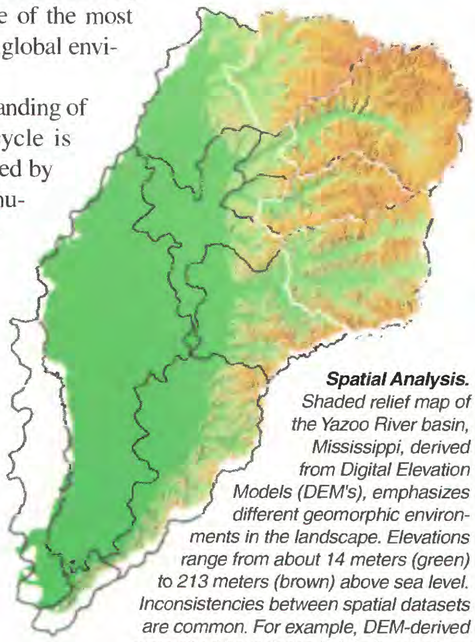

***The Greenhouse Effect**, which is part of the Earth's climate system, maintains temperatures far warmer than would be expected from direct solar heating. Most of the incoming solar radiation (short wavelength, shown in purple) is absorbed and converted to long wavelength radiation (shown in red), at or near the Earth's surface. Heat results from the absorption of some long wavelength radiation by atmospheric gases, including water vapor ($H_2O$), carbon dioxide ($CO_2$), methane ($CH_4$), and nitrous oxide ($N_2O$). The greenhouse effect is the retention of this heat in the atmosphere. Some human activities increase the amount of greenhouse gases, primarily $CO_2$, resulting in more heat being retained in the atmosphere.*




***The Global $CO_2$ Budget** can be defined as the balance of $CO_2$ transfers to and from the atmosphere. The transfers shown here represent the $CO_2$ budget after removing the large natural transfers which are thought to have been nearly in balance before human influence. Units are in metric tonnes of carbon per year. Budget figures shown here are for the 1980's.*

concentrations are presently increasing as a result of human activities. This increase may affect the global climate. Therefore, it is important to understand the global budget of atmospheric $CO_2$. This challenge has proven to be one of the most difficult problems in global environmental research.

Lack of understanding of the global carbon cycle is perhaps best illustrated by the scientific community's inability to balance the present global $CO_2$ budget. Before human influences transfers were approximately equalized so that the amount of $CO_2$ in the atmosphere had remained nearly constant for thousands of years. The increase in atmospheric $CO_2$ over the last 100 years has primarily resulted from the burning of fossil fuels. However, the concentration of $CO_2$ in the atmosphere is also influenced by human modifications of the land surface by harvesting forest products, farming, and urban development. These transformations drastically alter the cycle of carbon accumulation and distribution on the land surface.



***Spatial Analysis.*** *Shaded relief map of the Yazoo River basin, Mississippi, derived from Digital Elevation Models (DEM's), emphasizes different geomorphic environments in the landscape. Elevations range from about 14 meters (green) to 213 meters (brown) above sea level. Inconsistencies between spatial datasets are common. For example, DEM-derived watershed boundaries (white lines) above four major reservoirs differ from watershed boundaries (black lines) derived from a national hydrologic unit dataset. Such inconsistencies will be resolved prior to spatial analysis of storage and distribution of carbon in the landscape.*

The amount of human induced $CO_2$ appears to exceed the amount accumulating in the atmosphere and oceans. The carbon needed to balance the $CO_2$ budget (about 1 to 2 billion metric tonnes per year) is probably absorbed by land plants and ultimately incorporated in soils or sediments. Accumulating evidence points toward this carbon being absorbed in the temperate latitudes of North America, Europe, and Asia.

Carbon cycle interactions can be extremely complex. For example, agricultural practices increase erosion, which tends to decrease the fertility and carbon content of soil, the largest carbon reservoir on the land surface. Some of the carbon depleted by erosion from upland soils is transported downslope and buried at the base of hillslopes, on floodplains, and in reservoirs. Once buried, most of this carbon is no longer available for exchange with the atmosphere. Fertilizer application, however, enhances soil productivity, and freshly eroded substrates enhance the rate of organic matter formation. Thus, while land-surface disturbance increases erosion, which degrades the soil, the combined effects of agriculture and the redistribution of carbon across the landscape may promote carbon accumulation on land.

The primary goal of the Mississippi Basin Carbon Project is to quantify the interactive effects of land-use, erosion, sedimentation, and soil development on carbon storage and nutrient cycles within the Mississippi River basin. The project includes spatial analysis of a wide variety of geographic data; site-specific studies of relevant processes; and estimation of whole-basin and subbasin carbon and sediment budgets, and development and implementation of terrestrial carbon-cycle models. These studies are directed at estimating rates of carbon accumulation, decomposition, erosion, transport, and deposition; and particularly at assessing the sensitivity of these rates to climatic, hydrologic, topographic, and land-use gradients. By investigating how fundamental processes influence carbon in soils and sediments of the Mississippi River basin, we hope to take a step toward understanding the global significance of human effects on land-based carbon cycling.

***Site Specific Studies.*** *Vibracore sampling of marsh peat in the Mississippi River Delta, southern Louisiana. Vibracore is a coring procedure that uses mechanical vibration rather than rotation to force a sampling tube into unconsolidated saturated material. Investigations in the Delta are a collaboration between the USGS and the U.S. Army Corps of Engineers, New Orleans District. (Photo courtesy of Jack McGeehin, USGS, 1996.)*


***Data integration*** *is accomplished through statistical and spatial analysis of model results.*

Studies of carbon, sediment, and nutrient budgets in the Mississippi River basin will also provide valuable information relevant to many problems associated with human land use. Agricultural productivity is threatened by erosion and declines in soil fertility. Erosion and sedimentation are primary concerns in the management of water supplies and quality. Natural organic compounds play a critical role in the transport and storage of contaminants in waters and sediments. Carbon compounds account for most of the oxygen depletion associated with anoxia and eutrophication in lakes, streams, and coastal waters. An improved understanding of interactions between changes in the land surface and changes in the global carbon cycle is essential to predicting and coping with global environmental change.

*Helaine W. Markewich, Norman B. Bliss, Robert F. Stallard, and Eric T. Sundquist*
Graphic design by *Caryl J. Wipperfurth*
Shaded relief map by *Bruce B. Worstell*

COOPERATING ORGANIZATIONS
U.S. DEPARTMENT OF AGRICULTURE
Agricultural Research Service
Forest Service

*For more information contact:*
Program Coordinator
Global Change and Climate History
U.S. Geological Survey, Mail Stop 906
12201 Sunrise Valley Drive, Reston, VA 20192
(703) 648-6517
http://geochange.er.usgs.gov