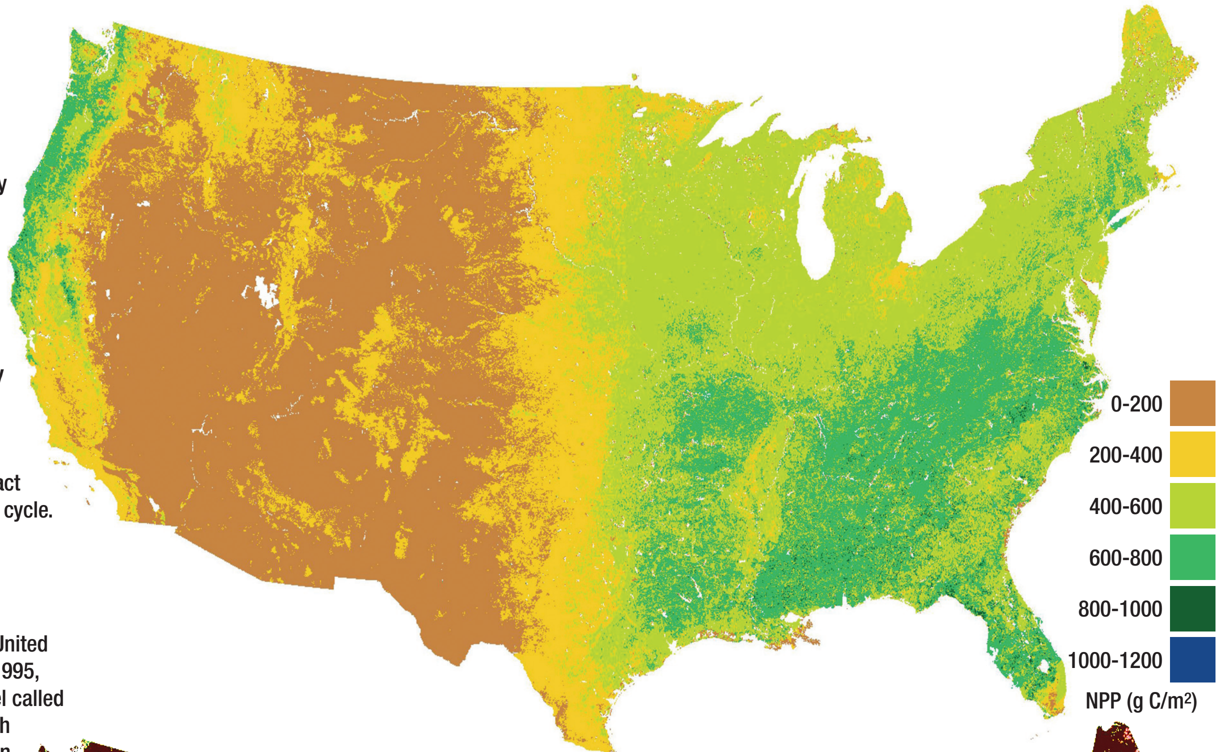
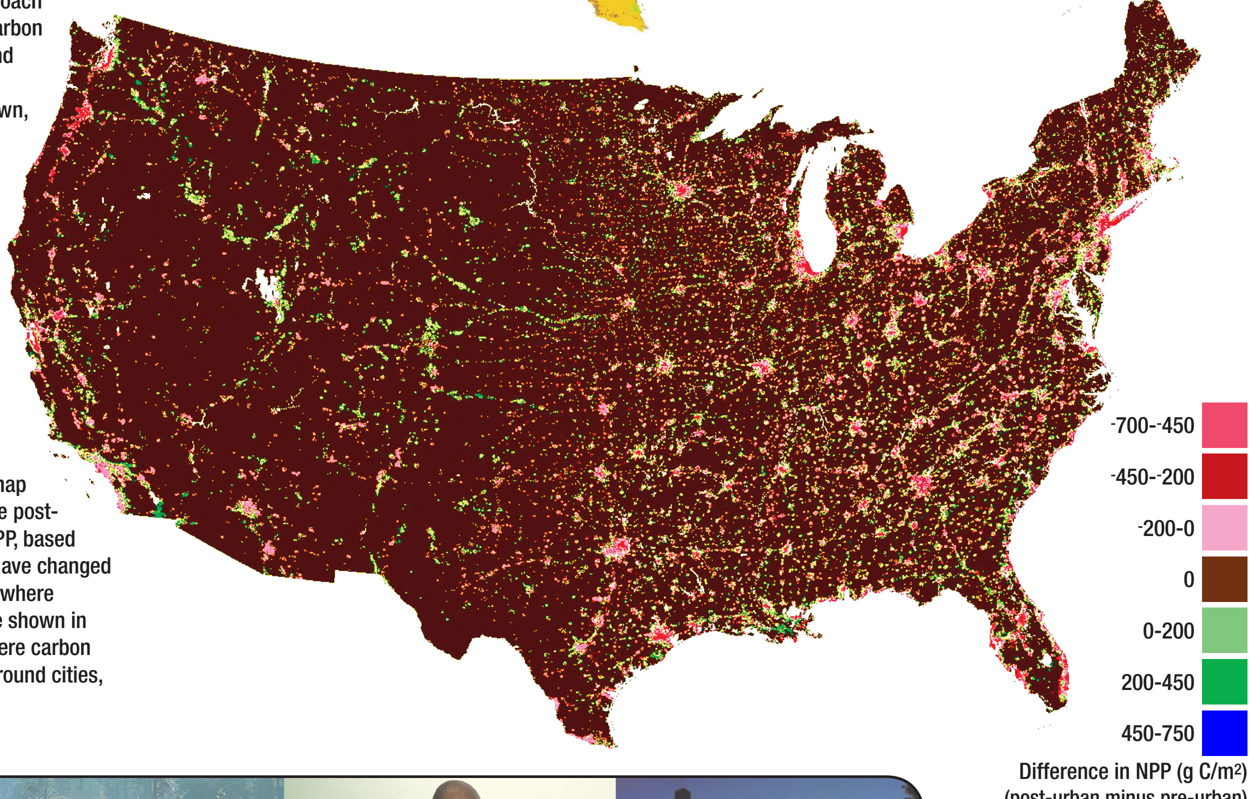
National Aeronautics and Space Administration

SCIENCE SERVING SOCIETY: CARBON MANAGEMENT

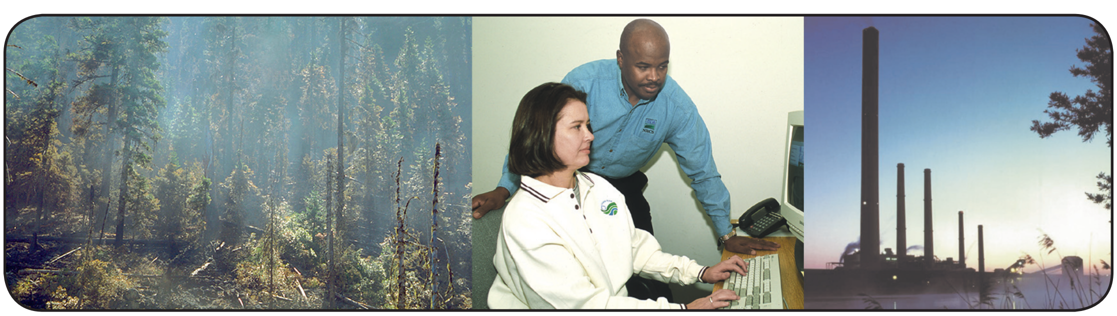
Carbon management is a key natural resource and policy issue. Scientists use NASA data and models to identify how much carbon is present in the various parts of the Earth system and how that amount may change in the future. Among the key questions is how converting natural landscapes to urban and developed areas changes the area's net primary productivity (NPP)—the amount of carbon stored by the landscape. NPP provides a "common currency" that allows scientists to quantify the impact of land transformation on the carbon cycle.



The top map shows NPP across the United States from October 1994 to March 1995, based on output from a carbon model called the Carnegie Ames Stanford Approach (CASA). Places that store more carbon appear green, such as Eastern and Pacific Northwest forests, while places that store less appear brown, such as the arid Southwest.



Scientists can compare modern "post-urban" estimates of NPP with a hypothetical "pre-urban" U.S. to get a sense of how widespread urbanization has changed the carbon storage "profile" of the U.S. The bottom map shows the difference between the post-urban and pre-urban values of NPP, based on the CASA model. Places that have changed little are shown in brown, places where carbon storage has increased are shown in greens and blues, and places where carbon storage has declined, primarily around cities, are shown in shades of red.



Informed carbon management enables more efficient energy production, helps efforts to offset the impact of climate change on society, improves agricultural efficiency, and inspires new technologies for reduction of carbon emissions.

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Overview of the Program

At present, an array of Earth observing satellites are in orbit, and additional launches both by NASA and others will continue throughout the next decade. Our ability to observe our home planet from space has never been greater. Increasingly, studies of the Earth focus on understanding the Earth's land, atmosphere, oceans, and life as a whole integrated system rather than as individual independent elements. NASA is an important contributor in this systems approach to Earth science studies.

In addition to providing Earth observing capabilities, NASA forms strategic partnerships with other government, academic, private, and international organizations. Through these partnerships, NASA's Earth science observations and measurements are linked to practical applications. NASA data, information, and predictive models help NASA's partners, and nontraditional users of Earth science, make timely and accurate decisions regarding management of resources and development of policy. The agency's goal is to maximize the benefit of science and technology to stakeholders by smoothly flowing Earth science data and information from NASA satellites to society.

Carbon Management

Carbon Dioxide (CO_2) is fundamental for life on Earth. Human beings exhale CO_2 as a waste product when they breathe, but plants absorb it in the life-sustaining process of photosynthesis—upon which human beings depend for the food we eat. CO_2 is also a naturally occurring greenhouse gas; its presence in the atmosphere helps moderate Earth's average surface temperature and keeps nighttime temperatures from plunging to extreme cold.

Over the millennia, the amount of CO_2 in the atmosphere has varied. Evidence is mounting that emissions of CO_2 from the burning of fossil fuels (oil, gas, and coal) combined with changes in land use and land cover resulting from human activities such as deforestation, biomass burning, and urbanization are changing the distribution of carbon among the land, atmosphere (in the form of CO_2), and oceans. The concentration of atmospheric CO_2 increased by more than 25% in the 20^{th} Century, an unprecedented rate of change. It continues to increase, and without mediation, could be 2.5 times greater by the end of this century than it was in 1900. The unprecedented increase in atmospheric CO_2 concentration is likely to have serious climate consequences. In fact, the change in the concentration of CO_2 in the atmosphere may constitute the greatest impact that humans have had on our home planet, and we are only now beginning to understand the potential impact this change may have on society.

Carbon management is a key resource management and policy issue of the 21^{st} Century. New technologies for reduction of carbon emissions and storage of carbon deep underground are options to achieve long term reduction in the concentration of CO_2 in the atmosphere. As these technologies are being developed and applied, a nearer-term reduction in the rate of increase in atmospheric CO_2 may be possible by increasing storage of carbon in soils, above ground biomass, and aquatic environments. Such carbon sinks currently absorb about 50% of the carbon emitted into the atmosphere annually.

The carbon management program element in the Applied Sciences Program of the Earth Science Division in NASA's Science Mission Directorate uses data and models from NASA's Earth science research to help operational agencies fulfill their mandates to manage carbon and support local, regional, national, and global policy and planning for control of carbon in the environment. NASA also collaborates with academic and government laboratories and operational agencies in the development, testing, and implementation of new technologies for measuring, monitoring, and validating carbon management practices.

Currently, several U.S. agencies are exploring the potential to sequester carbon in plants and soils. The United States Department of Agriculture's Forest Service, for example, is conducting research on forest plots across the country to understand how carbon is emitted and absorbed in forest ecosystems. NASA Earth science capabilities, observations and models, are helping the Forest Service scale up the information obtained on forest behavior in specific plots to understand the ability of forests to sequester carbon regionally and nationally. The Carbon Query and Estimation Tool (CQUEST) is a product of NASA Earth science now being evaluated by the Forest Service. CQUEST is an on-line resource that allows users to estimate and monitor carbon sequestration in above-ground biomass over large areas. The tool uses NASA Earth science data from the Terra and Aqua satellites' Moderate Resolution Imaging Spectroradiometer (MODIS) and from other sources as input for a NASA Earth science model called the Carnegie-Ames-Stanford Approach (CASA)—see front for example. The results from CASA provide the information useful to the Forest Service and others. CQUEST can help the community to manage carbon more effectively, to anticipate changes in atmospheric carbon concentration, and to lessen the potential impact of such changes.

The successful implementation of a carbon management system requires a synthesis of a wide range of environmental information. NASA Earth observing satellites provide a unique viewpoint for collecting such information, and afford us an unprecedented capability to observe the Earth as an integrated system. (See examples on the front.) Additional satellite launches, such as the National Polar–orbiting Operational Environmental Satellite System (NPOESS), its precursor, the NPOESS Preparatory Project (NPP), and the Orbiting Carbon Observatory (OCO), will increase both the quantity and the quality of input data available for decision support tools and highlight NASA's commitment to maximize the use of exploratory research results for the benefit of society.

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