Sequestration

PROGRAM facts

U.S. DEPARTMENT OF ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

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TERRESTRIAL SEQUESTRATION PROGRAM

Capture and Storage of Carbon in Terrestrial Ecosystems

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Background

Clean, affordable energy is essential for U.S. prosperity and security in the 21st century. Over half of the electricity in the U.S. currently comes from coal-fired boilers, with coal projected to account for over half of U.S. electricity generation through 2020 and beyond. From a global perspective, in developing nations coal use for electricity generation is projected to more than double by 2020. This continuing demand for fossil-fuel-based power and the associated rise in atmospheric carbon dioxide (CO_2) concentrations will require innovative ways to capture and store carbon.

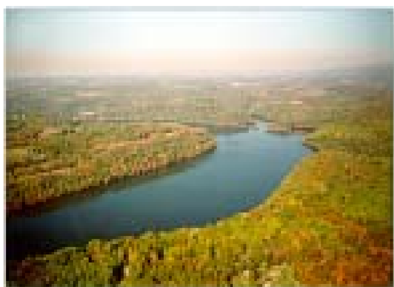
Terrestrial ecosystems, which include both soil and vegetation, are widely recognized as a major biological "scrubber" for CO_2. Terrestrial sequestration is defined as either the net removal of CO_2 from the atmosphere or the prevention of CO_2 emissions from leaving terrestrial ecosystems. Sequestration can be enhanced in four ways: reversing land use patterns; reducing the decomposition of organic matter; increasing the photosynthetic carbon fixation of trees and other vegetation; and creating energy offsets using biomass for fuels and other products. The terrestrial biosphere is estimated to sequester large amounts of carbon, about 2 billion tons (2 Gt) of carbon annually. The total amount of carbon stored in soils and vegetation throughout the world is estimated to be about 2,000 Gt +/- 500.

NETL

CONCURRENT BENEFITS

Terrestrial sequestration also offers significant additional benefits including:

- Creating wildlife habitat and green space
- Preventing soil erosion and stream sedimentation
- Boosting local and regional economies
- Reclaiming poorly managed lands
- Increasing recreational value of lands



Program Goal

"To provide economically competitive and environmentally safe options for offsetting the projected growth in CO_2 emissions.

Description

The U.S. Department of Energy's Office of Fossil Energy (FE) and Office of Science are jointly carrying out research on the capture and storage of carbon in terrestrial ecosystems. FE's current activities, which are managed by the National Energy Technology Laboratory (NETL), focus on enhancing the productivity of terrestrial ecosystems through the application of soil amendments, such as coal-combustion byproducts and biosolids produced at wastewater treatment facilities. The goal of the program is to provide economically competitive and environmentally safe options for offsetting the projected growth in CO_2 emissions. The cost of the options is in the range of $10/ton of avoided net costs for sequestration. The efforts are based on fostering partnerships between landowners, biomass and biofuels industry representatives, government agencies, and energy producers, such as coal companies and utilities. This partnering will help to determine the best approaches for increasing the amount of carbon sequestered in soils and vegetation.

Project Summaries

Applied Terrestrial Sequestration Partnership

The Applied Terrestrial Sequestration Partnership, an integrated research program led by Los Alamos National Laboratory (LANL)and NETL, is taking a leading role in developing breakthrough technologies and applications for terrestrial carbon sequestration.

Ecosystem Dynamics Understanding both ecosystem dynamics and economic issues is critical to the success of terrestrial sequestration as a policy option. Marginal lands (forest, farm, range, or industrial) can serve as a barometer for climate change and are ideal field sites for investigating terrestrial sequestration. This study uses a multi-disciplinary approach, integrating lab and field studies with the CENTURY model. The result will be a fundamental understanding of how changes in the plant community are reflected in carbon inventories and a detailed economic analysis of carbon sequestration in reclamation sites.

Advanced Plant Growth The research team, including partners at the Ohio State University, the University of Southern Maine, the National Energy Technology Laboratory, and the University of California at San Louis Obispo uses plant metabolites to optimize terrestrial carbon sequestration at reclamation sites. Metabolites will increase plant growth rates, biomass volume, and carbon dioxide uptake–maximizing sequestration potential. DNA-based methods are being used to fingerprint soil bacterial and identify their role in nutrient recycling. Field studies assess microbial response to changing water and temperature conditions.

Soil Carbon Measurements An integrated research team is working to develop new field-deployable, laser-based instruments for measurement and characterization of soil carbon. These instruments will revolutionize the practice of soil carbon science and allow for a more accurate accounting for terrestrial carbon sequestration. Instruments will be calibrated to a wide variety of soils and tested in the field. Results will be compared with traditional carbon measurements with respect to accuracy, cost, and time.

Enhancing Carbon Sequestration and Reclamation of Degraded Lands with Fossil Fuel Combustion Systems

Oak Ridge National Laboratory (ORNL) and Pacific Northwest National Laboratory (PNNL) are teaming with Ohio State University and Virginia Polytechnic Institute to determine the best way to increase the carbon sequestration potential of land previously disturbed by mining, highway construction, or poor land management practices. The team will focus on the use of amendments derived from paper production, biological waste treatment facilities, and solid byproducts from fossil-fuel combustion to identify and quantify the key factors necessary for the successful reclamation of degraded lands. The results will be summarized in a set of guidelines containing practical information about matching amendment combinations to land types and optimum site-management practices. Long-term field studies will be designed and site(s) recommended for the demonstration and further optimization. (ORNL and PNNL are part of DOE's Center for Enhancing Carbon Sequestration in Terrestrial Ecosystems [CSiTE] which is run by the DOE Office of Science.)

Carbon Capture and Water Emissions Treatment System at Fossil-Fueled Electric Generating Plants

The Tennessee Valley Authority and EPRI are partnering to demonstrate and assess the life-cycle costs of integrating electricity production with enhanced terrestrial carbon sequestration. The project is being conducted on coalmine spoil land at the 2,558 megawatt (MW) Paradise Station (Kentucky). This station, which burns bituminous coal and is currently equipped with flue gas desulfurization (FGD) for SO_2 control and is set to begin using selective catalytic reduction for NO_x control, will use the byproducts from these control systems to amend the mine soils. Treated water generated by the FGD system will be used to irrigate the soils. Benefits include: use CCBs to improve reclamation sites and carbon sequestration, development of a passive technology for criteria pollutant release reduction in water, development of a wildlife habitat and green space, generation of Total Maximum Daily Load (TMDL) credits for water and airborne nitrogen, and development of additional forest lands.

Terrestrial Sequestration turns unproductive land into new green space and wildlife habitat.

Enhancement of Terrestrial Carbon Sinks through Reclamation of Abandoned Mine Lands in the Appalachian Region

Stephen F. Austin State University, working with TXU (Texas Utilities) and Westvaco, is investigating storing carbon in trees on abandoned mine lands in the Appalachian region. Researchers are studying the potential for reclamation and reforestation and the development of a free-trade system for carbon credits. The focus is on developing an environmentally safe way to use mined lands and accomplish long-term carbon sequestration. Growth and yield models will be applied to commercial tree species in order to quantify the maximum amount of carbon that can be stored. Discounted cash-flow analyses will be conducted and the soil expectation value will be calculated to predict the per ton cost of carbon sequestration. A "carbon credit" market between landowners and utility and coal companies will be investigated, as well as analysis of the impact of sequestration on the local economy.

Application and Development of Appropriate Tools and Technologies for Cost-effective Carbon Sequestration

The Nature Conservancy will be working in close collaboration with U.S. based companies (including General Motors and American Electric Power) and NGO partners to study how carbon dioxide can be stored more effectively by changing land use practices and investing in forestry projects. The project will focus on gaining cost-effective, verified measurements of the long-term potential of various carbon sequestration and land use emissions avoidance strategies. The project will use newly developed aerial and satellite-based technology to study forestry projects in Brazil and Belize to determine their carbon sequestration potential, and will also test new software models to predict how soil and vegetation store carbon at sites in the United States and abroad.

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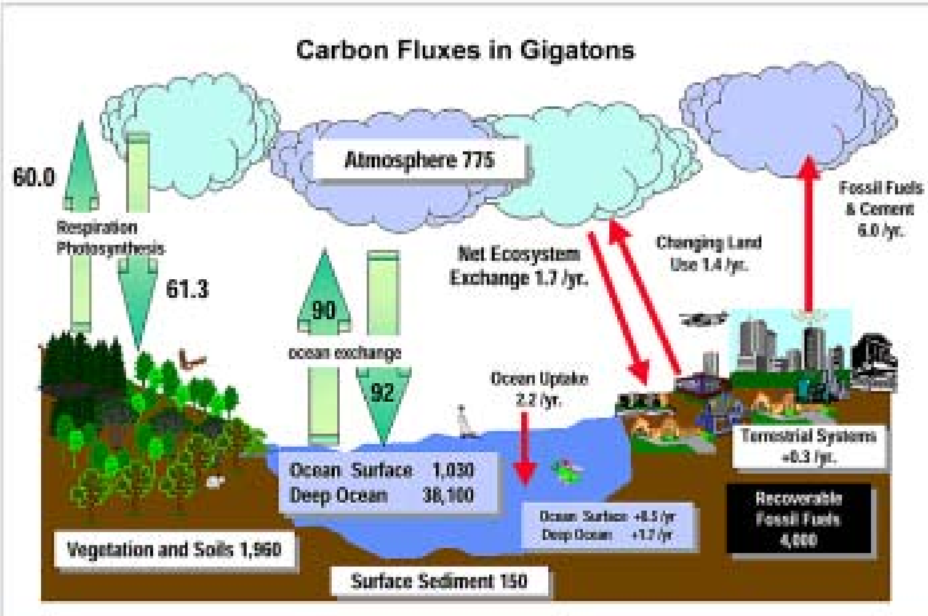

The Global Carbon Cycle

The figure above presents a simplified version of the global carbon cycle. The large arrows represent natural paths of carbon exchange and the small arrows represent the human or anthropogenic contributions to the carbon cycle. The flow of carbon is measured in billions of metric tons (gigatons).

The locations where carbon is stored are called "sinks."

These carbon "sinks" are immense. The atmosphere contains about 750 billion metric tons of carbon dioxide, the ground contains about 2,190 billion metric tons of carbon dioxide, and the oceans contain about 40,000 billion metric tons of carbon dioxide.

The arrows show the yearly exchange between these sinks. Plants and soils "give" about 60.0 billion metric tons of carbon dioxide to the atmosphere and "take" about 61.3 billion metric tons of carbon dioxide. The difference is the ability of green plants to "fix" carbon by photosynthesis.

The ocean absorbs 92 billion metric tons of carbon dioxide, which is slightly more than the 90 billion metric tons of carbon dioxide that is absorbed by the water. These are the main "fluxes" or flows of carbon that occur in nature.

The anthropogenic flux of carbon comes from two major sources. The larger of the two is from the burning of fossil fuels for electricity and cement production at 5.5 billion metric tons of carbon per year that is released to the atmosphere. The smaller of the two is the exchange of this carbon dioxide from land use changes that results in 1.4 billion metric tons of carbon dioxide being released to the atmosphere. 1.7 billion metric tons of carbon dioxide is absorbed by the land, resulting in a net exchange of +0.3 billion metric tons per year.

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