

### 3.2.3.2 MEASURING AND MONITORING SYSTEMS FOR FORESTS

#### Technology Description

Forest systems provide a significant carbon sink and can contribute to GHG emissions. To mitigate GHG effects, advanced technology is needed to measure and monitor forest and wood product processes, pools, and fluxes to better manage these systems to reduce and mitigate emissions, and to enhance carbon sinks. Measurement systems should be integrated using a multitiered approach combining national inventories, remote sensing, land-based measurements, and intensive monitoring on experimental sites. Additional profiles on measuring and monitoring systems for greenhouse gases in general can be found under “Enhancing Capabilities to Measure and Monitor Emissions.”

#### System Concepts

- GHG (fluxes and pools) inventory and measurement systems are a collage of measurements, covering broad temporal and spatial scales, methods, and technologies. No current inventory system provides the comprehensive coverage across scales needed to understand and manage GHG across the United States.
- An integrated approach is needed that combines national inventories, remote-sensing data, regional and site studies and measurements, experimental data, and modeling capabilities into a comprehensive observational and analysis system.
- Technology advances are needed in (1) enhanced remote-sensing data collection and analysis, (2) expansions and enhancements of extensive inventories systems for large-scale, landscape, and integrated resource measurements, (3) in situ instrumentation and monitoring systems for intensive monitoring, (4) specialized measurement and characterization systems for soils, and (5) integrating measurements and data.
- Global positioning and inertial measurement infrastructure, and remote and in situ sensors for soil, plant and microclimate characterization and monitoring

#### Representative Technologies

- The USDA Forest Service’s Forest Inventory and Analysis Program and the Natural Resources Conservation Services’ National Resources Inventory provide the basis for a national carbon inventory and annual changes in carbon pools for forest, pastures, and croplands.
- Wide range of technology such as global positioning systems, satellite and aircraft based remote sensing, in situ electrical, magnetic, optical, chemical, and biological sensors, and scientific instruments.

#### Technology Status/Applications

- LIDAR and RADAR remote-sensing methods are being developed and tested for 3-D imaging of forest structure. Additional work is needed to integrate remote and land-based measurements.
- Low-cost, portable, real-time measurement systems are not available for soil monitoring and other in situ measurements.

#### Current Research, Development, and Demonstration

##### RD&D Goals

- Reduce uncertainty associated with the national carbon inventory by improving coverage of national inventories and analyses of changes.
- Develop understanding of underlying processes of biological and ecological processes in order to develop improved monitoring systems and use systems to validate models for mitigation actions.
- Improve and develop low-cost, portable, real-time sensors and measuring systems for in situ measurements.
- Provide integration and systems design of remote sensing and ground-based carbon pool and GHG fluxes measurements technology using multitiered system.

##### RD&D Challenges

- National inventory systems were not designed for carbon and other GHG measurements and have not been adequately supported to develop complete wall-to-wall, comprehensive inventories of carbon pools and fluxes among the pools and atmosphere.
- There is little understanding of forest soil processes in the storage and allocation of carbon. This information is paramount for the development of management systems and practices that enhance carbon sequestration.

- The broad range of required scales, cover types, and ecosystems will require the development of (1) remote sensing integrated with other measurements at various levels of coverage, duration, and intensity, and (2) low-cost, robust measurement systems that can effectively be used at different scales. Sites covered need to be expanded as part of extensive monitoring and intensive measurement systems.
- A great wealth of information and data will be acquired by enhanced measurement and monitoring systems. Advances are needed in the technology to manage, process, translate, analyze, and transform this information into predictive and decision-making tools.
- Develop measuring and monitoring systems for carbon pools in wood products in use and in landfills.

**RD&D Activities**

- Efforts are underway to improve carbon inventory systems and reduce the uncertainty of our national inventory.
- Improvements are being made in remote sensing, sensor, instrumentation, and measuring system technology through Federal, university, and private collaboration.
- Current technology needs to be more fully deployed; and new, innovative technology should be piloted and demonstrated to accelerate deployment.

**Recent Progress**

- The USDA Forest Inventory and Analysis Program assesses the U.S. forest structure and condition and is the basis for our nation’s carbon inventory in concert with information provided by the National Resource Inventory. Periodic national carbon inventories have been produced using this data.
- The AmeriFlux network is being completed, which will improve the understanding of carbon pools and fluxes in large-scale, long-term monitoring areas and intensive experimental sites.
- Research programs are in place that can (1) provide inventory of carbon stocks, (2) understand and quantify biological processes, (3) model and predict climate impacts and management strategies, and (4) develop effective, low-cost management systems.
- Partnerships have developed among government, university, and private research organizations to improve greenhouse gas measurements.

**Commercialization and Deployment Activities**

- Global positioning systems are currently in use and can provide geo-references for carbon measurements.
- Current technology is not fully deployed; efforts are needed to demonstrate and increase the efficiency of such technologies.
- Specialized remote sensing technology is being developed and will be deployed in the near term for the measurement of greenhouse gas emissions and carbon stocks.
- A comprehensive, integrated, multiple-tier measuring and monitoring system needs to be fully developed and deployed.

**Market Context**

- Improved technology for carbon measurements can provide security in credit trading.
- Enhanced measurement systems can provide input for the optimal design, deployment, and management of forest and wood product systems that will provide additional carbon sequestered and ancillary benefits.