

FOREST SERVICE

RESEARCH AND

DEVELOPMENT

BIOENERGY

AND

BIOBASED

PRODUCTS

STRATEGIC

DIRECTION

2009-2014



FOREST SERVICE RESEARCH AND DEVELOPMENT

Research and Development (R&D) in the Forest Service, U.S. Department of Agriculture (USDA), is a primary source of forest research and scientific information for the Nation. Our mission is to develop and deliver knowledge and innovative technology to improve the health and use of the Nation's forests and rangelands. Working with partners across public and private sectors, we provide knowledge and technology to sustainably manage forests and rangelands to provide goods, services, and values now and into the future.

A NATIONAL ISSUE

Decreases in the availability and security of petroleum supplies, coupled with global increases in demands, are driving energy, transportation, food, and fiber prices higher. Dependence on petroleum threatens U.S. energy, economic, and environmental security. A nation with insecure or inadequate energy resources is at risk of being unable to feed and house its people, care for its environment, and sustain its economy. Biomass is the single renewable resource that has the potential to supply a significant portion of U.S. liquid transportation fuels, chemicals, and substitutes for fossil fuel-intensive products. The Energy Independence and Security Act of 2007 (Public Law 110-140) mandates that by 2022, the United States will replace 36 billion gallons/year (bg/yr) of transportation fuels with biofuels, with at least 16 bg/yr coming from cellulosic feedstocks. In 2007, then-Forest Service Chief Gail Kimbell set a goal of replacing 15 percent of current U.S. gasoline consumption with ethanol from wood—approximately 21 bg/yr—to meet energy goals and to help reduce greenhouse gas emissions (Kimbell 2007). Replacing 20 percent of U.S. transportation fuels with biofuels, substituting biopower for 7 percent of energy use in industry and utilities, and increasing biobased products produced to 27.7 million tons using materials from America's farms and forests will come from a well-established, economically viable biobased products and bioenergy industry.

President Barack Obama called for doubling renewable energy production (2009). The President also created the Biofuels Interagency Working Group (Biofuels and Rural Economic Development 2009), which is charged with developing the Nation's first comprehensive biofuel market development program; coordinating infrastructure policies affecting the supply, secure transport, and distribution of

biofuels; and identifying new policy options to promote the environmental sustainability of biofuels feedstock production.

Wood is an abundant, sustainable, homegrown cellulosic resource that can significantly contribute to meeting 30 percent of U.S. petroleum consumption from biomass sources by 2030 and help create a more stable energy future, improve environmental quality, and increase economic opportunities.

A NATIONAL OPPORTUNITY

Vision: America's forest resources significantly contribute to U.S. energy security, economic development, and environmental quality.

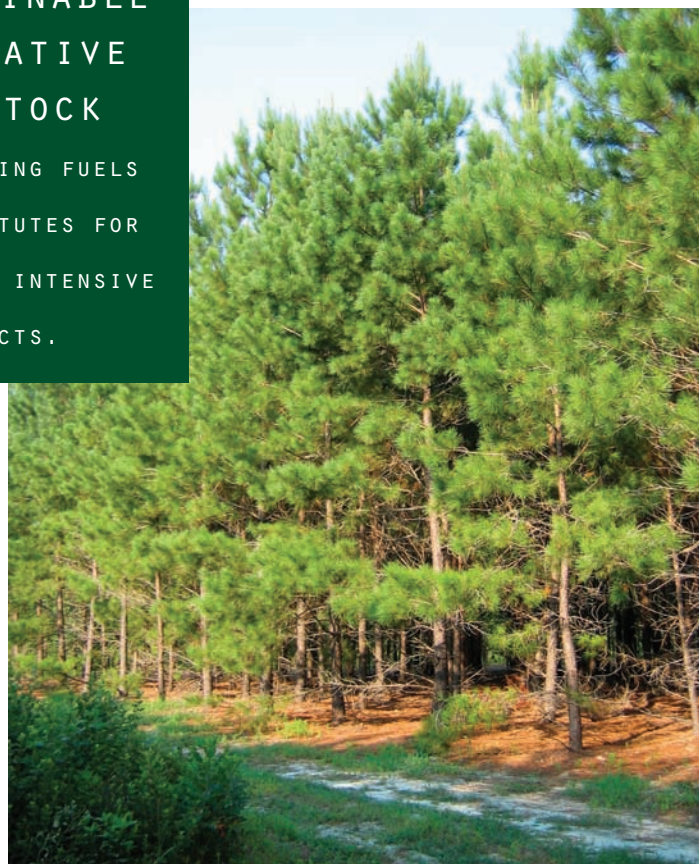
Our vision is that in 5 years, the United States will have:

- Wood-based energy and bioproducts that enhance the environment.
- Secure, sustainable, renewable energy sources.
- Strong rural economies.

Our Nation's forests comprise a sustainable, strategic asset in achieving and enhancing U.S. energy security, economic opportunity, environmental quality, and global competitiveness. Woody biomass is a sustainable alternative feedstock for producing fuels and substitutes for fossil fuel-intensive products. Appropriately managing and transforming the Nation's renewable and abundant forest biomass

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Ten-year-old, short-rotation loblolly pine.



resources into cost-competitive, high-performance biofuels, bioproducts, and biopower can:

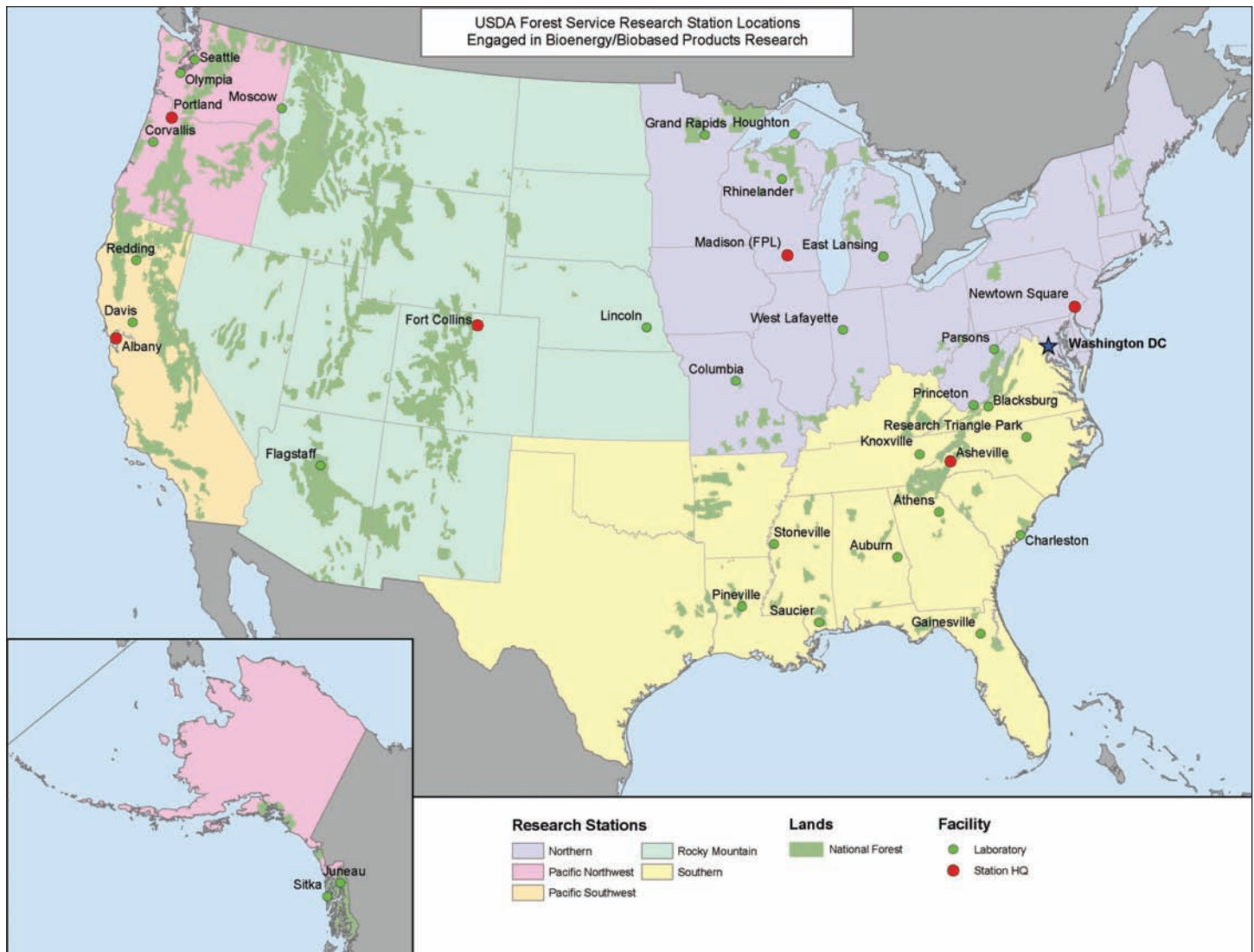
- Reduce greenhouse gas emissions.
- Move the Nation away from petroleum.
- Create domestic economic growth.
- Help create a more stable energy future.
- Improve environmental quality.
- Increase economic opportunities.
- Provide the benefits of actively managed forests in the landscape.

One of the greatest challenges facing forest managers in the United States on both public and private land is restoring, maintaining, and enhancing the health and productivity of forest systems. In many forests at risk of loss from fire, insect, or disease, this requires the removal of large quantities of small-diameter and low-quality wood that currently has little or no commercial value. Because this material has little commercial value in today's markets, removing it often

requires large expenditures with no, or minimal, current economic returns. As a result, far fewer acres are being treated than needed. Removal and use of biomass also provides associated benefits, such as improved ecosystem health, reduced wildfire fuels, improved wildlife habitat, and enhanced watershed protection on both public and private lands. Converting this material into energy and biobased products provides numerous benefits, including improved forest health and productivity and economic opportunities.

Active management to sustain the health, diversity, and productivity of the Nation's forests provides local, regional, and national benefits. Goods, services, and values derived from actively managed forests include wood and nonwood products; jobs, businesses, and income; enhanced water and air quality, water supply, wildlife habitat, and recreation opportunities; and reduced fire and pest risk and loss. Improved economic value of the land as a result of active management can help offset urban footprints by keeping working lands working.

Figure 1. Current Forest Service R&D bioenergy and biobased products research unit locations.



A sustainable, renewable bioenergy and biobased products sector is a growing source of green jobs in the U.S. economy. Research and development can create these jobs both in the short term, through research execution, and in the long term as results are demonstrated and deployed, and the economic sector develops.

R&D has a long history of providing results in the area of bioenergy and biobased products. Since the 1970s, significant accomplishments have been made in harvesting, genetics, silviculture, and conversion processes related to energy. R&D has a broad research program, developing the science and technology to sustainably produce forest feedstocks and significant amounts of biofuels and biobased products from forest resources. Our work, and that of our partners, spans the range of developing sustainable management and harvest/recovery systems for alternative resources; improving conversion and biorefinery technologies for cost, energy, and environmental efficiencies; developing innovative uses for wood and wood components; and improving the cost competitiveness of wood for energy. Figure 1 indicates where current R&D bioenergy and biobased products research activities are housed. R&D coordinates with other Forest Service deputy areas and actively partners with USDA agencies, other Federal departments and agencies, universities, nongovernmental groups, and industry. R&D supports related work through Agenda 2020¹ and represents the United States on one International Energy Agency Task for biomass energy.

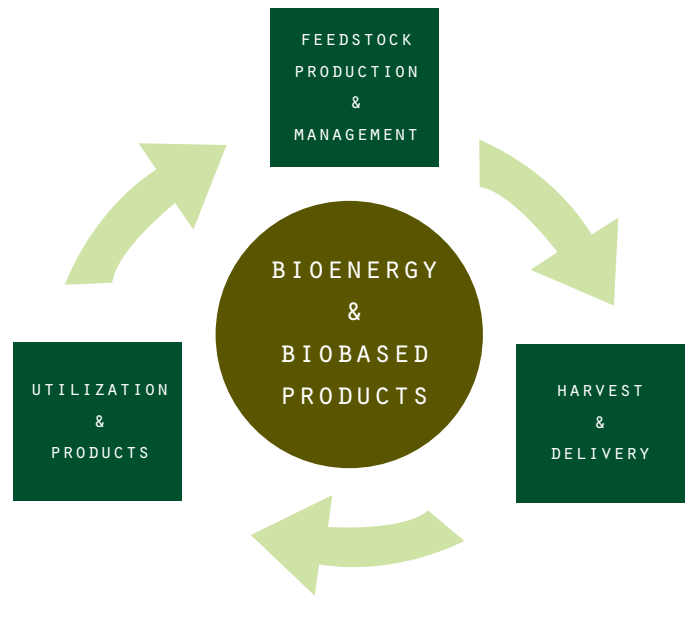
¹ <http://agenda2020.org/>.

Small-diameter woody biomass.



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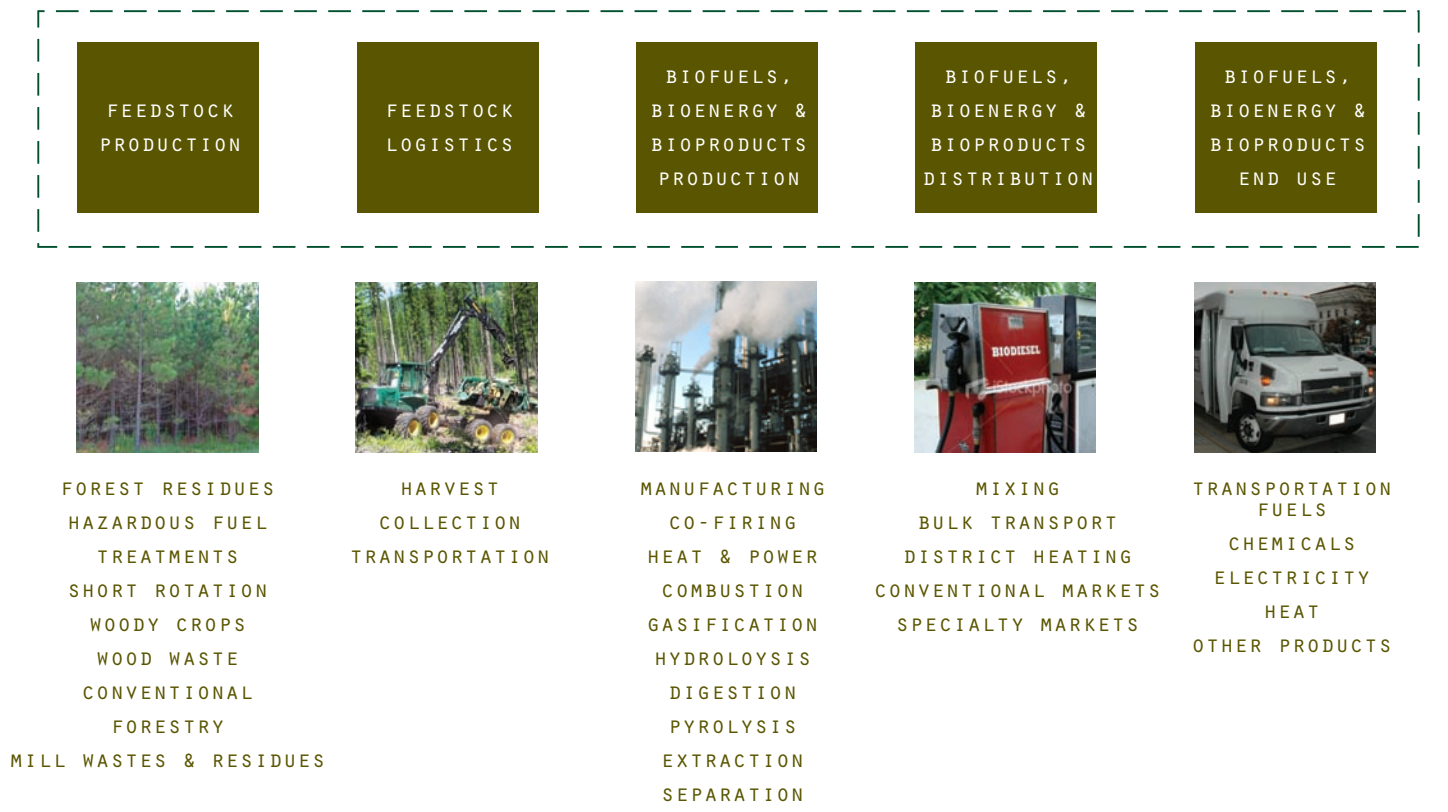
Figure 2. *Integrated Bioenergy and Biobased Products Research Program.*



PLANNING CONTEXT

This strategy document was developed in the context of a number of other planning activities, including the Forest Service’s 2007–2012 Strategic Plan (USDA Forest Service 2007); Forest Service research station strategic plans; the Forest Service Woody Biomass Utilization Strategy; the Strategic Framework of Forest Products and Utilization Research and Development (USDA Forest Service 2006); the USDA Strategic Plan for FY 2005–2010; the USDA Research, Education, and Economics Mission Area Strategic Energy Science Plan; interactions with the broad forestry R&D community, academic institutions, nongovernmental organizations, and other government agencies to consider critical research and development issues in this area. Additional input was obtained at a workshop to discuss research needed for forest-based biomass, bioenergy, and biobased products. Using all this information, a set of research priorities in three broad areas was developed to coordinate and guide R&D bioenergy and biobased products research and development activities for the next 5 to 10 years. The agency will endeavor to execute this program of research and development to redeem its responsibilities in meeting national and regional bioenergy and biobased product goals.

Figure 3. Forest bioenergy and bioproduct supply chain.
 (Adapted from the National Biofuels Action Plan <http://www.usda.gov/documents/NBAP081208.pdf>)



INTEGRATED APPROACH

The R&D Biobased Products and Bioenergy research and development program integrates all aspects of sustainable production and management, harvest and delivery, and conversion and utilization research (figure 2), and spans the scale from molecular to global analysis. It considers the supply chain (figure 3) of forest bioenergy and bioproducts, with the goal of ensuring productive, sustainable, efficient, and affordable forest bioenergy systems and options. While our scientists generally do not work directly on distribution and end-use research, we do work collaboratively with other agencies and partners to ensure that our results are valuable in the supply chain context.

The work outlined in this strategy will build on a long history and significant body of research on long-term soil and forest productivity, genetics and tree breeding, silviculture, water quality, forest operations, wood products, wood structure and chemistry, microbiology, enzyme technology, chemical engineering, economics, assessments, inventory, and life-cycle analysis. Specific research will be targeted to fill critical gaps identified as this strategic direction is implemented. The R&D Bioenergy and Biobased Products research program takes an integrated approach in developing

options, strategies, systems, and practices for the sustainable production of forest goods, services, and values.

The creation of a sustainable bioindustry producing biofuels and bioproducts on a significant scale is critically dependent on having a large, sustainable supply of biomass with appropriate characteristics at a reasonable cost; cost-effective and efficient processes for converting wood to biofuels, chemicals, and other high-value products; and useful tools for decisionmaking and policy analysis. The R&D bioenergy and biobased products research program is focused on delivering value in these three areas.

GOALS

Goal 1: Provide the Nation with sustainable and economical forest biomass management and production systems. Capturing the potential of forest biomass resources will not happen without addressing some major challenges, such as developing a reliable and sustainable feedstock supply; understanding and quantifying land-use change and competition; and reducing costs for growing, recovering, and transporting feedstocks. Critical areas of research include (1) developing management and utilization options, systems, and practices so that landowners and land managers can effectively integrate biomass production into management

activities, and (2) developing the science and technology for short-rotation woody cropping systems—purpose-grown wood. Meeting this goal requires research in silviculture, genetics, genomics, physiology, soils, pest management, and forest operations research. It will build on a significant body of research, including long-term soil and forest productivity studies, genetics and tree breeding, water quality research, and forest operations research.

Products expected include:

- Forestry best management practices for sustainable expanded biomass removal.
- New varieties of woody crops that are fast growing, high-yielding, pest-resistant, and water- and nutrient-use efficient.
- Synthesis of environmental outcomes of forest biomass production approaches.
- Forest biomass management systems and technologies to offset impacts and enhance environmental outcomes.
- Improved harvest, collection, handling, and transportation systems for woody biomass.
- Cost and equipment information and options for field processing to improve efficiency and mitigate impacts.
- Strategies to integrate forest systems into agricultural landscapes to provide services and income.
- Sustainable management and utilization systems that

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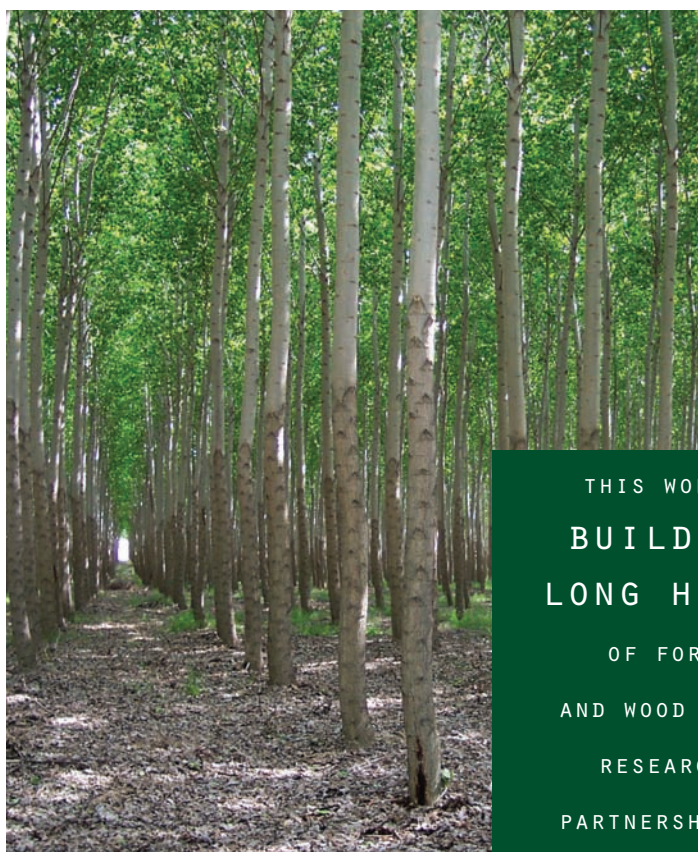
Biofuels pilot plant research facility.

integrate bioenergy feedstock production with biomass and residue management, forest health and fuels reduction treatments, and production forestry.

Goal 2: Provide the Nation with competitive biofuels and biopower conversion technologies and bioproducts that reduce greenhouse gas emissions and fossil fuel use. Challenges exist in developing competitive technologies and processes that can reduce the cost and increase the efficiency of producing biofuels, products, and power. Efficiencies can be achieved through methods for increasing the yields derived from biochemical and thermochemical conversion of forest feedstocks, as well as developing new product



Loading biomass chips for transport.



Hybrid poplar plantation.

THIS WORK WILL
 BUILD ON A
 LONG HISTORY
 OF FORESTRY
 AND WOOD PRODUCTS
 RESEARCH AND
 PARTNERSHIPS WITH
 INDUSTRY AND ACADEMIC
 INSTITUTIONS.

- Increased fermentation rate, yield, and inhibitor tolerance of fermenting organisms.
- Quantification of the rate-limiting factors and biochemistry of five-carbon sugar transformation.
- Robust biorefining technologies that can utilize a variety of lignocellulosic feedstocks.
- Value-added chemicals and fuel from thermochemical platforms, including pyrolysis and gasification.

Goal 3: Provide the Nation with information and tools for decisionmaking and policy analysis.

Working with our partners, R&D provides information to analyze and inform policy and develops a variety of tools useful for on-the-ground decisionmaking by landowners and land managers. These information sources and data include national and regional assessments—such as the Resources Planning Act assessments and the Forest Inventory and Analysis data—that provide information on past and expected trends in markets, products, demand, supply, and forest productivity, harvest, condition, and distribution. Examples of recent products contributing to this goal include the Billion Ton Report (Perlack and others 2005), life-cycle analysis efforts such as CORRIM (Consortium for Research on Renewable Industrial Materials)² (Bergman and Bove 2008, Lippke and Edmonds 2006), MyFTP (My Fuel Treatment Planner)³, and FRCS (Fuel Reduction Cost Simulator)⁴.

streams from this material. Critical areas of research include (1) developing wood-based biofuels, chemicals, and products that economically substitute for petroleum-based materials and (2) developing economically efficient biorefinery pathways and processes. This work will build on a long history of wood products research and partnerships with industry and academic institutions. It will include research in conversion processes, wood quality, advanced composites, advanced housing, wood chemistry and physics, microbiology, enzyme technology, chemical engineering, economics, and marketing.

Products expected include:

- Feedstock characteristic database, feedstock selection, sorting, and preprocessing technology optimized for various biofuels conversion technology platforms.
- Integrated bioenergy and biofuels production processes to diversify product lines, expand markets, and provide value-added energy options for conventional wood-processing facilities.
- Research programs in developing green chemical products from forest biomass.
- Efficient biomass deconstruction techniques for chemical and fuels production through fermentation.
- Lignin characterization and value-added products from lignin.

Products expected include:

- Higher resolution and consistent national and regional tools for more accurate assessment of forest bioenergy resources.
- Mapping products to identify potential sites for short-rotation woody energy crops.
- Models to assist with identification of opportunity zones and site selection for bioenergy facilities considering supply, transportation, water, and infrastructure.
- Sustainability criteria for forest bioenergy feedstocks.
- Life-cycle analysis and assessment tools for all aspects of forest bioenergy and bioproducts, including carbon and greenhouse gas accounting.
- Integrated models of future land use patterns, goods and services delivery, and markets as influenced by expanded bioenergy production.
- Logistics and decision support tools to reduce costs of treatments involving biomass removal and improve harvest and transport efficiency.

2 <http://www.corrim.org>
 3 My Fuel Treatment Planner, http://www.fs.fed.us/pnw/data/myftp/myftp_home.htm
 4 Fuel Reduction Cost Simulator, http://www.fs.fed.us/pnw/data/frcs/frcs_home.htm

OUR CHARGE

Forest Service research stations and the Forest Products Laboratory will work collaboratively across organizational, political, and institutional boundaries to accomplish this program of research and deliver the needed outcomes. The Forest Service Bioenergy and Biobased Products R&D Program will work through outreach and partnerships with other Federal agencies, universities, and industry to help develop the next generation of specialists and researchers for bioenergy and biobased products.

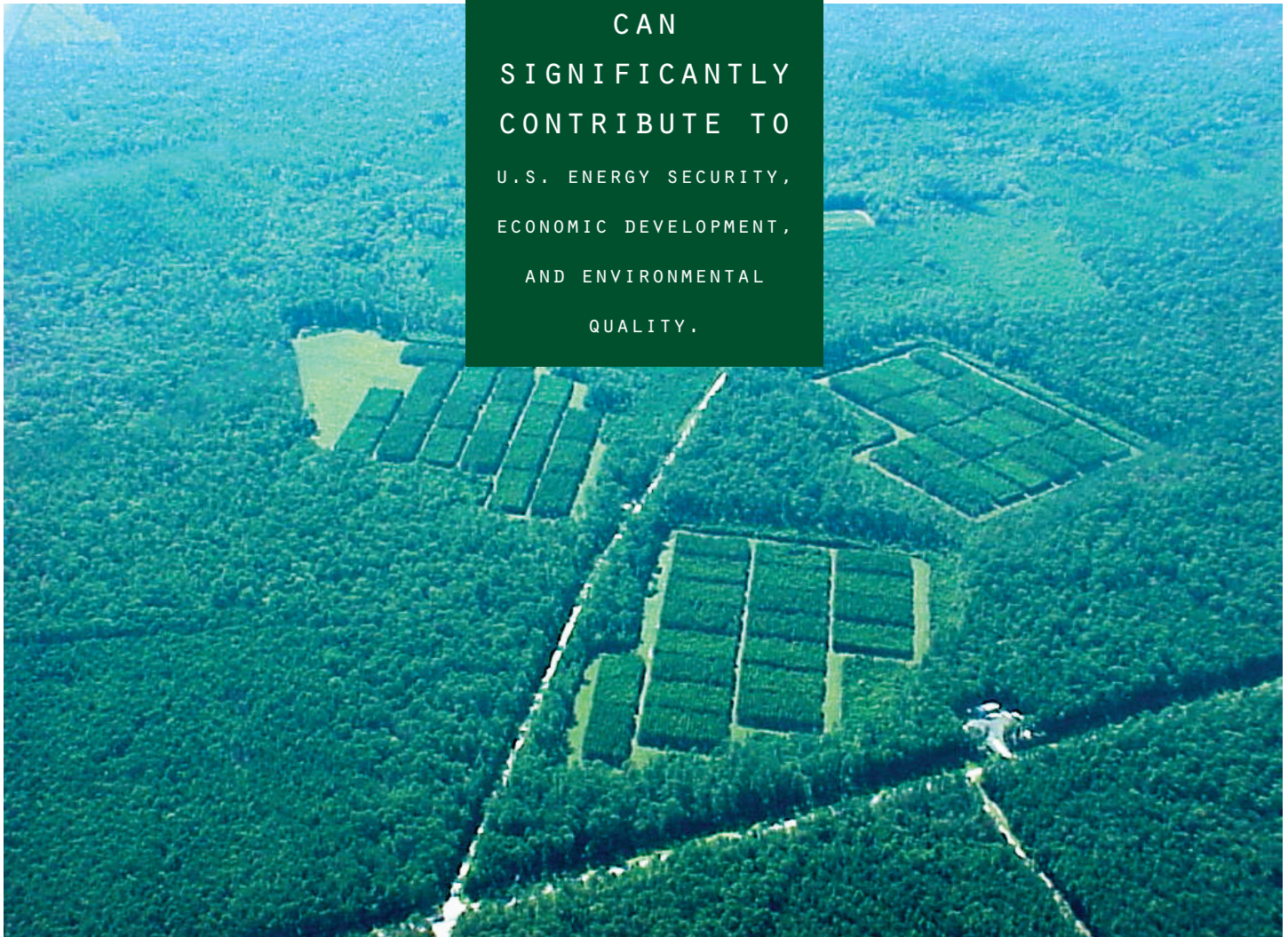
R&D will provide science and technology to sustainably provide the quantities of wood needed for bioenergy and bioproducts, maintain and enhance forest health and productivity, reduce costs, and increase efficiency. Through research and development, America's forest resources can significantly contribute to U.S. energy security, economic development, and environmental quality.



Quantifying biomass harvest.

THROUGH RESEARCH AND
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Long-term soil productivity site on the Croatan National Forest in North Carolina.

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