

USDA Forest Service research and development – caring for the land and serving people

*Andrzej Bytnerowicz*¹ ✉ and *Ann M. Bartuska*²

¹ USDA Forest Service, Pacific Southwest Research Station, Forest Fire Laboratory, 4955 Canyon Crest Drive, Riverside 92507, California, USA, phone: +1 951 6801562, fax: +1 951 6801500, e-mail: abytnerowicz@fs.fed.us

² USDA Forest Service, The Washington Office, Washington, D.C. 20250, USA

INTRODUCTION

Total forested area in North America is 677.5 million ha (32.7% of land area), which is 17.1% of the global forests. Total area of the U.S forests is 303 million ha, which is the 4th largest in the World behind the Russian Federation, Brazil and Canada.

In 1876, the United States Congress created the office of Special Agent in the Department of Agriculture to assess the quality and conditions of forests in the United States. In 1881, the office was expanded into the Division of Forestry. The Forest Reserve Act of 1891 authorized withdrawing land from the public domain as “forest reserves” managed by the Department of the Interior. In 1901, the Division of Forestry was renamed the Bureau of Forestry. The Transfer Act of 1905 transferred the management of forest reserves from the General Land Office of the Interior Department to the Bureau of Forestry, henceforth known as the US Forest Service (<http://www.fs.fed.us/aboutus/history/>). Presently the agency is part of the US Department of Agriculture (USDA). The USDA Forest Service (USDA FS) manages public lands, provides assistance in management of the privately-owned forested lands, and does research. Major divisions of the agency include the National Forest System, State and Private Forestry, and the Research and Development (R&D) branches. The R&D branch provides research support for forests and range management and helps in knowledge and technology transfer to the National Forest System and the State and Private Forestry.

The United States currently has a system of 155 national forests, 20 national grasslands, and 79 research and experimental forests, as well as other special areas, covering more than 193 million acres of public land (Adams et al. 2008). The USDA FS has evolved into a 30,000 employee agency that manages the national forests for a number of multiple uses, including recreation, timber, wilderness, minerals, water, grazing, fish, and wildlife (<http://www.fs.fed.us/aboutus/history/>). As of fiscal year 2010, the USDA FS has a total budget authority of \$5.15 billion, of which 42% is spent fighting fires (<http://www.fs.fed.us/aboutus/budget/>).

The mission of the USDA FS is: to sustain the health, diversity, and productivity of the Nation’s forests and grasslands to meet the needs of present and future generations. Its motto is: caring for the land and serving people. As a lead Federal Agency in natural resource conservation, the USDA FS provides leadership in the protection, management, and use of the Nation’s forest, rangeland, and aquatic ecosystems.

USDA FOREST SERVICE RESEARCH AND DEVELOPMENT

The USDA Forest Service Research and Development (USDA FS R&D) consists of five geographically-based research stations, the International Institute of Tropical Forestry, and the Forest Products Laboratory and works at the forefront of science to improve the health and use of our Nation’s forests and grasslands. Re-

search has been part of the USDA FS mission since the agency's inception in 1905. Today, some 2,300 USDA FS employees, including more than 500 scientists work in a range of biological, physical, and social science fields to promote sustainable management of Nation's diverse forests and rangelands. Their research covers a large area of the US land, with programs in all 50 states, US territories, and commonwealths. The work has a steady focus on informing policy and land management decisions, whether it addresses invasive insects, degraded river ecosystems, or sustainable ways to harvest forest products. The researchers work independently and with a range of partners, including other agencies, academia, nonprofit groups, and industry. The information and technology produced through basic and applied science programs is available to the public for its benefit and use. In recent years the USDA FS R&D budget has been relatively stable with approximately \$312 million in 2010 (<http://www.fs.fed.us/research>).

In the 20th century, the main mission of the USDA FS was maintaining sustainability of forests and ranges from a perspective of providing enough wood and water for the growing nation and future generations. During most of the 20th century there was a general perception that the Nation had unlimited resources of those commodities. In the 21st century, a notion of sustainable forested lands for future generations has changed its meaning. The USDA FS has adopted an ecosystem approach to management of forests and ranges that integrates ecological, economic, and social factors to maintain and enhance the quality of the environment to meet current and future needs. Through implementation of land and resource management plans, the Agency ensures sustainable ecosystems by restoring and maintaining species diversity and ecological productivity that helps provide water, timber, recreation on its lands including wilderness areas, as well as minerals, fish, wildlife, and aesthetic values for the current and future generations (MacCleery and Rudis 2009). Management of forests and ranges is quite different than in the past and is characterized by large scale disturbances and uncertainty regarding the future. Another important characteristic of the present mission of the Agency is recognition of the importance of connecting rural areas with the growing urban systems. Major challenges facing the USDA

FS resource managers in the 21st century are: changing climate; large-scale disturbances, such as drought, fire, air pollution, and insects and diseases; and loss of open-space and growing urban expansion. These challenges have to be dealt with an understanding that the present-day public is engaged and has strongly defined views regarding utilization and management of the Federal lands. Under all these circumstances, the USDA FS R&D emphasizes: (1) Evaluating risks to natural resources (adaptation); (2) Estimating role of forestry and agricultural activities in greenhouse gas emissions and carbon sequestration (mitigation); (3) Developing practical management strategies and approaches, and (4) Providing science and information to support decision-making.

Accordingly, the USDA FS R&D develops and delivers knowledge and innovative technology to improve the health and use of the nation's forests and rangelands in the following Core Programs: (1) Resource Management and Use; (2) Wildland Fire; (3) Inventory and Analysis; (4) Invasive Species; (5) Water and Air; (6) Wildlife and Fish; and (7) Recreation. All these programs are executed with an understanding of problems of the rapidly and unpredictably changing global climate. Planning in advance and being proactive are the key features of the present management decisions. This new approach is much more effective and is in contrast to the past practices when reacting was taking place after disturbance or extreme events had already happened or when management planning was not taking into consideration presently occurring climate change (Bosworth et al. 2008).

FOREST HEALTH

A warmer climate in North America affects forests directly through soil moisture stress and indirectly through increased extent and severity of disturbances. Stress complexes (combinations of biotic and abiotic stressors), compromise the vigor and ultimate sustainability of forest ecosystems. Across western North America, increased water deficits accelerate the normal stress complex experienced in forests that involves combination of multi-year drought, insects, and fire. Symptoms of prolonged drought and insects are currently manifested in extensive dieback of pine species

in the pinyon-juniper forest of the US Southwest. Air pollution and high stand densities from fire exclusion have weakened mixed-conifer forests of the Sierra Nevada. Bark beetles are proliferating and killing millions of hectares of dry forest in the northern interior of western North America, setting up the prospect of large and intense wildland fires. Fire and insect mortality have also exceeded previously recorded levels in both interior and south-central Alaska, possibly precipitating extensive ecosystem changes, while extensive permafrost degradation is causing many other changes (McKenzie et al. 2009). Tree mortality in the US forests increased from about 0.8 million ha in 1998 to about 3.8 million ha in 2008 (Tkacz et al. 2008). The current outbreak of bark beetle is the largest ever seen in North America and affects coniferous forests throughout the western US states extending into British Columbia in Canada (Fig. 1). The USDA FS R&D addresses these issues by evaluating and modifying forest management practices in cooperation with forest practitioners of the USDA FS National Forest System. Increased spatial heterogeneity, in terms of appropriate species composition, age, structure, etc., have been suggested as tools that may help in increasing resistance of forests to a combination of various stressors in conditions of changing climate (Tkacz et al. 2008).



Fig. 1. Tree mortality in US forests increased from ~2 million acres in 1998 to ~9.5 million acres in 2008. Example – nearly complete mixed conifer stand mortality in the Deschutes National Forest near Bend, Oregon (photo – courtesy of Andrzej Bytnerowicz)

FOREST FIRES

All the above described disturbances causing massive forest dieback result in increasing area of forests consumed by fire (Fig. 2). In North America the area and intensity of wildland fire have been growing alarmingly during the past decade as a result of climate change (higher temperatures, reduced water supply, and drought) and the effects of past management practices which tended to increase fuel loading in forest systems. During the past 10 years, almost every year has seen an increase in total numbers of wildfires and the surface area burned over the previous year. Over 90% of the area burned in North American in the past five fire seasons has been consumed by only 1% of the fires. This fact indicates that a few large fires are burning over larger areas. Additionally, the intensity and spread rates of these fires are often beyond the accepted fire indices used by forest managers to describe fire danger and intensity. These huge fires that burn for weeks over whole landscapes are called Mega Fires. Mega Fires are very difficult and dangerous to control or extinguish. Smoke from wildland fire has become an increasingly significant health hazard to human populations. Additionally, air pollution emitted or formed as the result of wildland fires, especially elevated ground-level ozone, particulate matter and atmospheric nitrogen deposition has been affecting human health and contributing the observed forest health decline (Bytnerowicz et al. 2009).

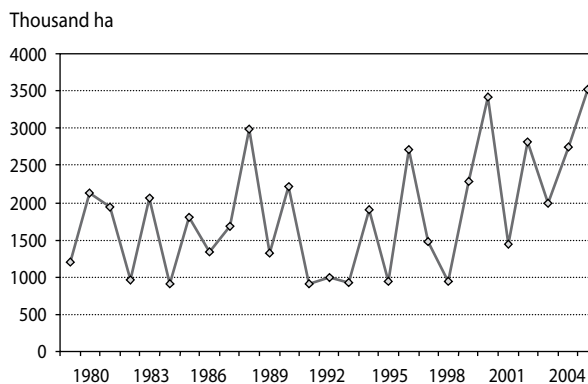


Fig. 2. Area of wildland fires in the United States has increased in recent years

CARBON SEQUESTRATION

Interest in terrestrial carbon sequestration has recently increased in an effort to explore opportunities for climate change mitigation. Carbon sequestration in forests and wood products helps to offset increasing emissions of carbon dioxide to the atmosphere caused by deforestation, forest fires, and fossil fuel emissions. Sustainable forestry practices can increase the ability of forests to sequester carbon dioxide while enhancing other ecosystem services, such as improved soil and water quality. Planting trees and improving forest health through thinning and prescribed burning are some of the means to increase forest carbon in the long run. Harvesting and regenerating forests can also result in net carbon sequestration in wood products and new forest growth. In response to the US government, business, and individual commitments to reduce carbon dioxide emissions, carbon is now a priced environmental commodity in the global marketplace (<http://www.fs.fed.us/ecosystemservices/carbon.shtml>). A synthesis of present understanding of carbon sequestration and resources in the US forests has been just published by the USDA FS scientists (Ryan et al. 2010). Recently the USFS R&D has been actively involved in carbon sequestration inventories needed for evaluation of the effects of changing climate and determination of potential control strategies. The USDA FS has adopted the CarBon Management Evaluation Tool as a Voluntary Reporting (COMET-VR) as the decision support tool for estimating carbon storage and greenhouse gas emissions (<http://www.cometvr.colostate.edu>).

ADAPTING TO CLIMATE CHANGE

Mitigating greenhouse gas emissions through carbon sequestration is only one response to climate change. As managers of forest and range ecosystems, we also are concerned with adaptation strategies to climate change and climatic variability. Some of that response is manifested in our response to increasing intensity and frequency of wildland fires, as well as to insect infestations and massive forest dieback. USDA FS has a great opportunity as an agency to lead responses to climate change based on the recently released new USDA Strategic Plan. The USDA FS has a leadership

role in implementing this plan, especially to ensure that the national and private forests are conserved, restored, and more resilient to climate change. This strategy should lead to enhanced water resources as well as mitigation and adaptation to climate change. The USDA FS has already done much to improve the resilience of US forests and grasslands, however, much more can be done in this regard. In order to do it the USDA FS Chief has established a post of a Climate Change Advisor to coordinate the Agency's climate change efforts. The Roadmap for Responding to Climate Change identifies the Forest Service priorities and is built on the 2008 Strategic Framework for Responding to Climate Change. The Roadmap lays out actions to incorporate adaptation, mitigation, sustainable consumption, and education objectives into the USDA FS existing programs, policies, and processes and builds strong partnerships with other agencies, tribes, States, communities, and citizens. To support these efforts, the Climate Change Resource Center (CCRC) provides information and tools to land managers to address climate change in project planning. The CCRC offers educational information, decision-support models, maps, simulations, case studies, and toolkit (<http://www.fs.fed.us/ccrc/>).

WATER RESOURCES

As mentioned before, one of the key strategic goals of the USDA is providing safe and reliable sources of freshwater since about 53% of Nation's water comes from the USDA FS lands. Therefore research on water resources, especially the watershed studies in the USDA FS experimental forests and ranges network, is of the highest importance for meeting this goal (Furniss et al. 2010). An integral part of this line of research are studies on anthropogenic threats to water quality, especially those related to environmental pollution, including atmospheric nitrogen deposition (US EPA 2008). There is a need for a better integration of research on water within the USDA, especially from a perspective of the effects of emissions of nitrogenous pollutant from agricultural and urban source areas on the receptor areas, including downwind forests and ranges. These effects may be quite pronounced in various receptor areas, such as the the San Bernardino

Mountains influenced by the Los Angeles smog containing high concentrations of nitrogenous air pollutants (Fenn et al. 1996).

FOREST PRODUCTS

The USDA FS Forest Products Laboratory provides information and technology to help manufacturers, mills, and small business operators become more efficient and friendly to the environment. New technologies respond to wood and fiber resources which are more diverse in species and size classes. Research and development also centers on underutilized species, recycling of wood and paper wastes, nonpolluting paper production, automation, performance testing and evaluation of new products. Research to evaluate inorganic and non-petroleum adhesives for wood products should provide new ways of making larger materials from smaller timber resources. Emphasis is also placed on developing value-added technologies to economically utilize small woody material to improve forest health and reduce fire hazard in the Western US. Other important and timely research activities provide reliable and sustainable sources of energy and materials (<http://www.fs.fed.us/research/rvur.shtml>). Recently, a large portion of research in the Forest Products Laboratory focuses on conversion of biomass to biofuels and bioenergy, one of the key technological priorities for the United States and the World. Finally, the Forest Products Laboratory is leading the way in looking at nanotechnology uses of cellulose and wood fibers for an emerging forest products industry (<http://www.fpl.fs.fed.us/>).

SOCIAL SCIENCES

The USDA FS social scientists assess how human behavior, values, social institutions, economic activities and demographic trends impact the availability, demand for and use of forests and grasslands. In addition, social scientists examine how agency land management decisions and policies affect communities and private landowners in proximity to public lands, under-served populations, and the general public. The disciplines and specialties of the Agency's social scientists include eco-

nomics, geography, sociology, social and environmental psychology, anthropology, archaeology, human ecology, political science and landscape architecture. Across these disciplines, a broad range of research topics are studied. Examples of those are: rural economic development and tourism, use of non-timber forest products, forest product markets, human perceptions of wildfire and prescribed fire, experiential aspects of wilderness, impacts of changing demographics on forest resources and management, outdoor recreation, and monetary and non-monetary resource valuation (<http://www.fs.fed.us/research/rvur.shtml>).

We realize that in this short article, only a partial picture of the USDA FS R&D could be presented. Readers interested in more comprehensive understanding of our activities and current accomplishments of are directed to annually published research USDA FS R&D highlights (<http://www.fs.fed.us/research/infocenter.shtml>).

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