COMMENTARY

Gap Analysis for Forest Productivity Research Investments

Eric D. Vance

The US forest sector is in the midst of an era of transition and opportunity. Expectations that forests are managed to sustain wildlife, water, soil, and other environmental values are increasing as are certification systems and state and national initiatives designed to insure those expectations are met. For landowners who expect a return on their forestry investment, a host of socioeconomic factors and competition from Asia and Latin America have created uncertainties in markets for conventional forest products and potential new ones for energy and biomaterials. Productive forests that generate fiber for a variety of markets are needed to capture emerging opportunities and provide incentives against converting forests to less environmentally beneficial uses. This can only be accomplished through forest technologies and management regimes firmly grounded in research; however, the infrastructure to support these advances has weakened because of reduced funding directed toward productivity objectives and declining industry capabilities. This convergence of factors requires that research gaps be identified to insure that limited research funds are efficiently allocated to address the highest priority questions.

The Gap Analysis for Forest Productivity Research Investments, supported by the US Forest Service in partnership with the National Council for Air and Stream Improvement, Inc. (NCASI), identifies critical research gaps related to increasing productivity and other values from managed forests and to characteristics and uses of wood for current and emerging markets. Articles in this special issue of the *Journal of Forestry* begin with a focus on wood properties desired in 21st century markets, followed by assessments of gaps related to fiber quality, intensive management, and biotechnology.

"Uses and Desirable Properties of Wood in the 21st Century" explores requirements for traditional and emerging wood markets and technologies ranging from building materials to new energy sources, chemical feedstocks, and nanotechnology. Although the United States remains the world's largest producer and consumer of forest products, global competition is impacting the balance of domestic production and consumption of conventional products such as paper, plywood, and lumber. These and other conventional uses are projected to expand and continue as the largest US wood markets for the foreseeable future, even as emerging markets for bioenergy and biomaterials increase. Examples of generally desirable wood properties include high uniformity, specific gravity and cellulose content, and low moisture. Properties required for some uses are more specific, such as low recalcitrant cellulose and high six-carbon sugar content for some biofuels and chemical feedstocks. By contrast, even needles and bark are acceptable feedstocks for thermochemical conversion to syngas and liquid fuels, which has less stringent requirements. Uncertainties in the direction and rate of socioeconomic and technological drivers of wood markets will require the flexibility to adapt, making an adequate research base all the more essential. Research gaps identified for wood uses and properties include (1) increase uniformity of wood properties from faster growing trees, (2) improve properties required for specific product categories, (3) develop products that are multifunctional and durable yet can still be recycled and reused, and (4) reduce energy consumption and emissions associated with product manufacturing.

"Enhancing Forest Value Productivity through Fiber Quality" focuses on quality defined as suitability for specific uses. Enhancing quality requires an understanding of physical, mechanical, and chemical properties of wood linked to key product characteristics. Desirable properties vary with scales that range from meters (e.g., knots and juvenile wood) to nanometers (e.g., fibers and chemical structures). As forest products become more diverse and specialized, technologies to measure and monitor fiber quality become more important. Critical gaps related to fiber quality research include (1) improve understanding of relationships between wood properties at different scales and product performance; (2) determine effects of physiological processes, genetics, silviculture, and environmental conditions on fiber quality; (3) incorporate fiber quality into models to enhance forest investments, management, and marketing; (4) improve robustness and affordability of field-based wood quality measurement technologies; and (5) improve scientific infrastructure to address these gaps.

"Research Strategies for Increasing Productivity of Intensively Managed Forest Plantations" describes the use and benefits of intensive management of loblolly pine in the Southeast, Douglas-fir in the Pacific Northwest, and hybrid poplar in the Midwest. Intensive management involves the manipulation of site resources, tree genetics, and stand structure to optimize tree growth and is most common on industrial ownerships. When practiced appropriately and under the guidance of forest certification systems and best management practices, intensively managed stands and associated forested landscapes provide clean water and wildlife habitat, allow more fiber to be grown on a limited land base, and provide economic incentives for landowners to retain their lands in forest. Intensive practices have increased forest productivity by up to sixfold over the past 40 years relative to unmanaged, naturally regenerated stands. Nutrition management, competing vegetation control, and site preparation practices that facilitate stand establishment account for much of this increase, with improved genetic stock developed from tree breeding programs contributing an increasing share in recent years.

Critical research gaps for ensuring that planted forests remain a sustainable and competitive source of fiber include (1) improve understanding and prediction of forest responses to intensive management; (2) incorporate ecophysiological, genetic, site, and wood quality parameters into tree improvement programs and growth models; (3) quantify the influence of repeated biomass harvests on sustainable productivity and develop practices to avoid or mitigate negative effects; (4) expand silvicultural research networks to examine responses across a range of sites; and (5) expand technology transfer and the use of improved genetic stock to a larger segment of landowners.

"Research Gap Analysis for Application of Biotechnology to Sustaining US Forests" describes forest biotechnology as consisting of three components. The first, quantitative genetics and genomics, is used to assess genetic variation in populations, the genetic basis of traits, and adaptation of populations to changing conditions. Advanced propagation technologies such as somatic embryogenesis are used to efficiently produce uniform, high-quality planting stock. Genetic engineering, the third component, refers to the addition of a gene or genes to an organism genome to introduce desirable characteristics and has been successfully used to confer resistance to insects, diseases, and herbicides in agronomic crops over the past two decades. Potential benefits of biotechnology to forestry are enormous and include enhancement of tree pest and disease resistance, productivity, wood properties for specific uses, and tolerance to adverse sites and changing environmental conditions.

Critical forest biotechnology research gaps include (1) improve performance and reduce costs of somatic embryogenesis-derived planting stock; (2) assess ecological risks associated with introducing transgenic trees in a range of environments; (3) assess effects of gene interactions and environmental conditions on tree growth using the Pine Genome Initiative genome sequence; and (4) use tree genetic diversity as a basis for introducing resistance, as done with chestnut blight and the American chestnut.

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LETTERS

In Defense of My Position

I read with interest the responses (March 2010 issue) to my letter to the editor in which I expressed disappointment that *JoF* published a book review that criticized the well-accepted scientific conclusion that global warming is real and largely due to anthropogenic activities. I was criticized for suppressing minority viewpoints and being uncollegial. Let me respond. First, climate change science is by no means settled, but the arguments are largely internal—how much, how fast, specific mechanisms or causes, counteracting tendencies, potential effectiveness of mitigation measures, etc.—and not about the essential claims themselves. I suggest reading or downloading the 2007 Intergovernmental Panel on Climate Change (IPCC) summary report (www.tinyurl.com/nmodsr) to understand the main evidence and conclusions. While I apologize for coming off as a bit exasperated and thus "uncollegial," there is nothing in the responses to my letter to the editor that addresses my fundamental concern. Second, while there are certainly a plethora of minority viewpoints that deny the consensus of climate change research, for any of them to be considered scientifically or professionally credible, it must provide some compelling rationale for disagreement: troubling anomalies, feasible alternative theories, testable hypotheses and predictions, etc. I'd be happy to read anyone's cogent and rational criticisms of the IPCC report's findings and conclusions in this or other SAF publications. Until then, I do not apologize for taking *JoF* to task over publishing personal opinions as professional judgments.

Travis Idol
Honolulu, HI

Clarification, Correction, and Comment

After reading Dr. Yang's letter in the March issue of *JoF*, I realized I should have provided more details regarding the long-term temperature trend for Pennsylvania. Although average temperature data for Pennsylvania may be downloaded from the cited National Oceanic and Atmospheric Administration (NOAA) web link, the equation did not appear on the web page. To increase transparency, I now provide the data, a graph, and methods used in developing the equation (www.sfws.auburn.edu/South/penn.HTML).

The reported narrow ranges for temperature and rainfall for species #34 (see Yang's Figure 2) are incorrect. Temperatures (5–95% range) reported by Natural Resources Canada (2008) for umbrella magnolia are annual (8.8–18.6°C), coldest period (−9.4–3.1°C), and warmest period (27.3–33.2°C). According to Natural Resources Canada (2008), the average annual rainfall of 1,068 mm for Philadelphia is not outside the "core" natural range (errors in Table 4) for umbrella magnolia (991–1,683 mm; www.glfc.cfsnet.nfis.org/mapserver/metadata.phtml?LAYER=73119) and Norway maple (691–1,105 mm; www.glfc.cfsnet.nfis.org/mapserver/metadata.phtml?LAYER=62637).

Norway maple (species #3) was introduced into Philadelphia by William Bartram in 1756. Because of its success as an urban tree, it has been planted by many homeowners and is now classified as an exotic invasive species. "Over the years Norway maple has naturalized throughout most of Pennsylvania, although it is more common in the southern half of the state" (www.paflora.org/Acer%20platanoides.PDF). It also grows farther south into Virginia and North Carolina. I have been told the sale and planting of this species has been banned in New Hampshire and Massachusetts.

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Growing Organizational Challenges

As a veteran Forest Service member, I was interested in the article on the Forest Service's "growing organizational challenges" by Greg Brown and others in the March 2010 issue of the *Journal of Forestry*. I anticipate a spate of comments from employee readers.

The study was ingenious in showing trends over time and separating administrative and management levels. It gave visible

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