Advancing the Science of Forest Hydrology

A challenge to agricultural and biological engineers

Devendra M. Amatya, R. Wayne Skaggs, and Carl C. Trettin

For more than a century, agricultural and biological engineers have provided major advances in science, engineering, and technology to increase food and fiber production to meet the demands of a rapidly growing global population. The land base for these technological advances has originated largely from forested lands, which have experienced dramatic declines over the past century. The resulting landscape is a mosaic of agricultural, forest, and urban lands that may not be sustainable with respect to the expected goods and ecosystem services, including water quantity and quality.

Forests are recognized as an integral component of the landscape, and maintaining their functional integrity is fundamental for the sustainability of ecosystems and societies alike. Tools and practices analogous to those developed to improve agricultural production and quantify environmental impacts are needed to ensure the sustainability of landscapes that include the entirety of ecosystem goods and services.

Agricultural and biological engineering involves the requisite disciplines to address issues associated with the sustainability of contemporary landscapes, extending well beyond the boundary of agricultural lands.

The development of hydrologic and water quality modeling tools (e.g., SCS CN method, SWAT, AGNPS, GLEAMS, DRAINMOD, EPIC, ANSWERS, etc.) is a good example. These models, developed primarily for agricultural catch-

ments, are routinely applied on landscapes that include forests and other land uses. Their reliability for assessing the impacts of best management practices (BMPs) depends heavily on the understanding of forest hydrologic and biogeochemical processes, which in most cases was not a primary focus of the underlying research and model development. The fact that the hydrology and water quality of undisturbed forested lands is generally used as a base-line reference for determining the impacts of BMPs emphasizes the importance of this issue.

The importance of forests in the landscape is often not reflected by their proportional area.

For example, wooded buffer zones around streams draining an agricultural catchment are recognized as a means for reducing nonpoint-source pollution from agricultural lands. Headwaters of streams in a landscape are generally forested and play a critical role in maintaining sustained water quantity and quality. Forests in the landscape also play a critical role in net ecosystem water balance, carbon sequestration, and greenhouse gas emissions, all of which may be related to climate change. In order to improve the effectiveness of designing landscape functions, and to help ensure sustainability, appropriate models are needed to characterize the biological, chemical, and physical processes of forested lands, so that their consideration is as accurate as that conveyed for agricultural and pasture lands.

The disparity in information is illustrated by the consideration of evapotranspiration (ET), the sum of water evaporation from the canopy (canopy interception), transpiration, and soil/litter evaporation. A review of current hydrologic models indicates that ET is weakly quantified for forested catchments, due to lack of specific information on vegetation data such as leaf area index (LAI), stomatal conductance, rooting depth, and soil moisture. It is important to accurately characterize these and other parameters and the processes they control, if models are to be applied to address issues of land use, climate change, and impacts of BMPs. Another example is the SCS-CN (curve number) parameter used to describe the surface runoff process in widely used hydrologic models. The availability of CN values is very limited for the complex mosaic of forest cover, including various species and ages of overstory and understory.

The technologies, (e.g., sensors, Doppler, LIDAR, radar, and satellite images) used in interpretation and model parameterization of topography, soils, land use/land cover, hydrometeorology, and vegetation parameters are basically the same for both agricultural crops and forests. Yet the relationships between forest eco-hydrologic processes and the remote sensing products are often poorly understood, leading to errors in model inputs and limiting the reliability of model applications. One way to address this problem is to extend and strengthen close collaboration of agricultural and biological engineers with biologists, ecologists, and tree physiologists to develop a better understanding of the ecosystem and improved methods for quantifying the processes and their inter-relationships. Such collaborations may include sharing long-term eco-hydrological data from the experimental watersheds across the geographical gradients in the country, such as those maintained by the USDA Agricultural Research Service and U.S. Forest Service.

ASABE can play an important role in advancing the knowledge of hydrologic and biogeochemical processes in forested lands.

The annual international meetings, specialty conferences, and symposia organized by ASABE serve as a key venue for disseminating results from important research and demonstration projects. Technical sessions on forest engineering and soil erosion have been presented at ASABE meetings for many years. For example, a specialty conference on forest and rangeland hydrologic issues took place in the late 1980s. Due to the increasing importance of forest hydrologic science and its application to addressing sustainable water resource issues on a much broader scale, ASABE engineers are increasingly challenged to develop innovative technologies and reliable tools and models. In recent years, technical sessions focused on eco-systems, land use and climate change, and water availability and quality have been presented at the ASABE annual meetings. In 2006, an international conference on "Hydrology and Management of Forested Wetlands" was sponsored by ASABE. More than 80 papers on state-of-the-art research findings were presented by ASABE engineers and scientists, as well as professionals from various related disciplines. The papers presented at those sessions can be found in ASABE's on-line technical library (http://asae.frymulti.com/toc.asp). These efforts are intended to expand collaborative opportunities, both within and outside the ASABE community, for research on the science of forest hydrology.

ASABE professionals are encouraged to be proactive in inviting their colleagues from other disciplines to work together to address the challenges in this important area.

Devendra M. Amatya is a research hydrologist, U.S. Forest Service, Center for Forested Wetlands Research, Cordesville, S.C., USA; damatya@fs.fed.us.

ASABE Fellow R. Wayne Skaggs is a WNR distinguished university professor, Department of Biological and Agricultural Engineering, North Carolina State University, Raleigh, USA; rwaynejudy@bellsouth.net.

Carl C. Trettin is a team leader/soil scientist, U.S. Forest Service, Center for Forested Wetlands Research, Cordesville, S.C., USA.