The Water Web

by Stephanie Worley Firley

Water quantity and quality issues affect every living thing on Earth, yet, until recently, methods for projecting possible future water supply scenarios were fairly limited. In the late 1990s, SRS scientists participating in several national-scale assessments of climate change science and climate-related impacts discovered "a frustrating lack of landscape-scale, integrated ecosystem models from which to draw projections of future hydrologic conditions," according to research ecologist **Steve McNulty**. So they set out to build their own hydrologic model—known as WaSSI—to examine how long-term climatic changes interacting with human factors could influence water availability.

WaSSI stands for the **Water Supply Stress Index**, which was originally developed in 2005 to assess the impacts of changes in temperature and precipitation, land use, and human population on the relationship between water supply and demand in the southern region of the United States. Now researchers with the **Eastern Forest Environmental Threat Assessment Center** (EFETAC) are expanding its scope.

"WaSSI is a comprehensive model that is being built and validated using data from NASA satellite imagery and measurements from more than 500 individual water and carbon monitoring sites around the world," says **Ge Sun**, EFETAC research hydrologist and WaSSI's lead developer. "It can simulate monthly water supplies as well as carbon sequestration—an essential ecosystem function for regulating climate—for approximately 2,100 watersheds across the entire continental United States."

EFETAC's WaSSI development team, including codevelopers McNulty and research hydrologist **Pete Caldwell**, intend to use the model results to help natural resource managers and policymakers make informed decisions when faced with the uncertainties associated with future environmental change.

"Water is a very powerful controller of ecosystem structure and function," explains Sun. "If you understand a forest's water cycle, you can tell a lot about the carbon cycle, biodiversity, and how the ecosystem will respond to change." WaSSI can also help a variety of other users such as educators, researchers, nongovernmental organizations, and the general public gain insight into the effects of global change on water, carbon, and biodiversity at both local and continental scales.

A range of projects are already using information generated by WaSSI, including Forest Futures projects by both SRS and the Northern Research Station.

The WaSSI model is also reaching an international audience. It has been successfully applied in Mexico and Brazil to help address natural resource and land use challenges, and will be applied to several countries in Africa and Asia to quantify potential impacts of land use practices on water quantity and quality as part of an effort to develop economic incentives for conserving watershed ecosystem services.

"This application of WaSSI represents a true international collaboration effort that benefits many people," says Sun. "This is especially true in regions with limited means for monitoring current or forecasting future water and carbon resources."

Southern forests are among the top providers of water supply in the Nation. (photo by Vekony Zoltan, courtesy of Dreamstime)

WaSSI's initial release as a Web-based application is planned for mid-2011. Once the model is online, users will be able to simulate and graph their own scenarios based on climate variations, land cover changes, and human population growth to assess the effects of multiple stresses on water and carbon cycling. In early 2012, WaSSI will offer users a mapping feature to visualize simulation results. WaSSI's developers say the model will continue to evolve over the next 2 to 5 years.

"We are actively pursuing a number of collaborations with universities and other Federal agencies to further expand WaSSI with additional data on watershed connectivity, seasonal streamflow patterns, water quality, and aquatic species," says McNulty. "Our goal is to produce a truly integrated model that can help answer a range of questions about future water and related issues in a changing world."

WASSI:

www.forestthreats.org/tools/WaSSI

For more information:

Ge Sun at 919-515-9498
or gesun@fs.fed.us

Recommended reading:

Sun, G.; Caldwell, P.; Noormets, A. [and others]. [In press]. **Upscaling key ecosystem functions across the conterminous United States by a water-centric ecosystem model.** Journal of Geophysical Research. [doi:10.1029/2010JG001573].

Sun, G.; McNulty, S.G.; Moore Myers, J.A.; Cohen, E.C. 2008. **Impacts of climate change, population growth, land use change, and groundwater availability on water supply and demand across the conterminous U.S.** Watershed Update. 6(2). 30 p.

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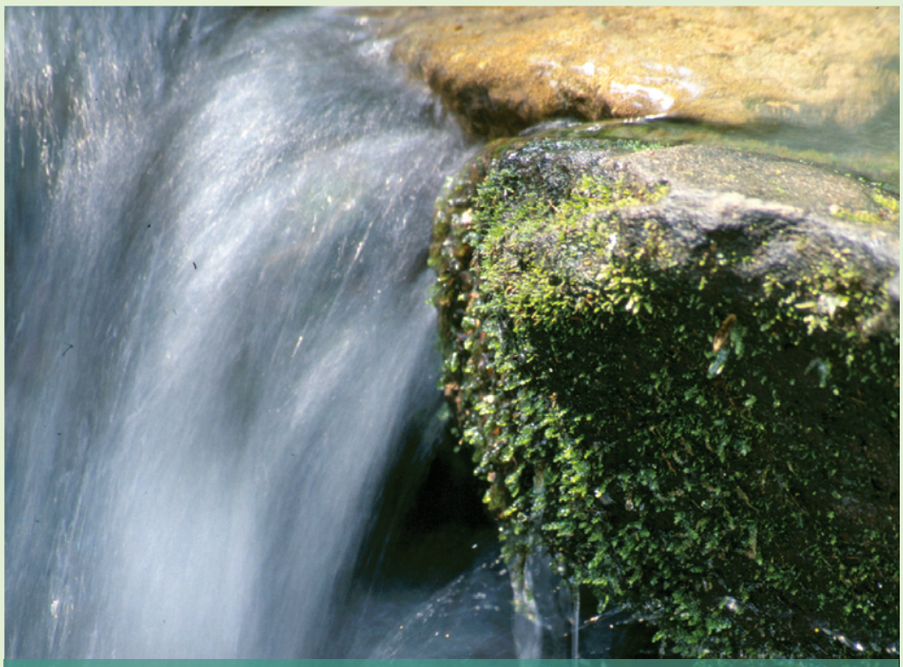
Stephanie Worley Firley is a biological science information specialist with EFETAC in Asheville, NC.



Water supplies in many parts of the United States are likely to decline under future climate change. (photo by USDA Forest Service)

What are WaSSI's Significant Findings?

- Based on the model's results, the WaSSI development team has drawn some general conclusions about future water availability in the United States, including:
- Southern forests are among the top providers of water supply and carbon sequestration in the Nation due to favorable climate conditions in the region for forest growth.
- Water supplies in many parts of the United States are likely to decline under future climate change due to increases in air temperature and declines in precipitation.
- Regardless of climate change, population growth will cause water stress problems in metropolitan areas.
- Predicted land use and land cover changes will have little effect on water quantity and water supply and demand relationships at the regional scale. However, these impacts can be significant for certain watersheds that have high degrees of change in land cover.
- Water stress is seasonal, with stress being highest in summer months when demand is high (mainly for irrigation) and supply is low. Reduction of water use by irrigation and domestic sectors can have a big impact on reducing water stress.
- Predictions of future water resources are uncertain due to uncertainty of climate change directions, especially for the Eastern United States.