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Using technology to save water in the US

By Dennis O'Brien, USDA–ARS

With climate change expected to raise temperatures worldwide and make rainfall patterns harder to predict, pressure is mounting on farmers – who use up to 60 per cent of the world's fresh water – to cut back on water use. Nowhere is the US water supply a more severe problem than in the Southwest, where droughts are common, reservoirs are closely monitored, and population growth is increasing demand.

ARS scientists in the southwest US are developing tools aimed at saving every possible drop with the help of satellite data, computer models, remote sensing, and other technologies. At the Arid Land Agricultural Research Center in Maricopa, Arizona, Doug Hunsaker is developing a sensor system that can determine the water needs of small clusters of crops. And at the Jornada Experimental Range in Las Cruces, New Mexico, Al Rango is beefing up computer models and the network of sensors scattered throughout the Rocky Mountains that help forecast runoff into the Rio Grande, a crucial water

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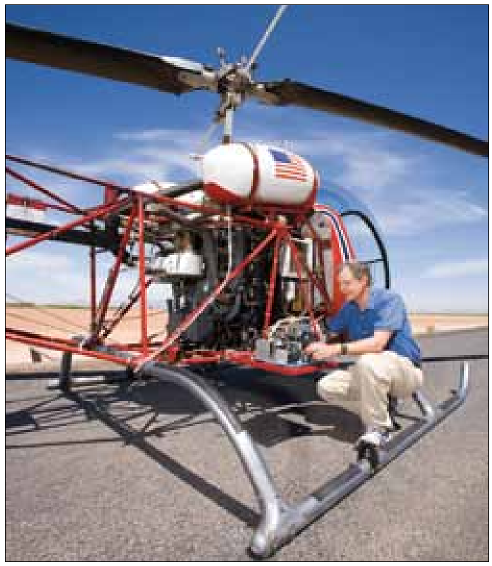

Before takeoff, physical scientist Andrew French prepares camera equipment for airborne multispectral imaging. The data collected is used to estimate crop water use.

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source for farmers in Colorado, New Mexico, Texas, and Mexico.

Impact of altered snowmelt

The Rio Grande gets more than half of its water from snow melting off the Rockies in southern Colorado and northern New Mexico, a region where population growth is straining water supplies. Climate change is expected to diminish those snowpacks and alter when water flows from them into rivers, says Rango, a hydrologist.

Snow starts melting in the New Mexico mountains in late March and continues until late August. But climate change could disrupt that cycle. Temperatures in New Mexico have increased about 2°C in summer and about 1°C in winter over the past 10 or 20 years. That rise is expected to continue, producing earlier snowmelt and altering when water becomes available for crops grown in the Rio Grande basin, such as cotton, onions, chilies, and pecans, Rango says.

With climate change expected to alter snowmelt patterns, researchers need better information. Rango is a principal investigator for part of a five-year National Science Foundation project that will help states collect better data on water supplies and help scientists better understand the effects of climate change on water supplies in the southwest. Research is also being conducted by New Mexico State University, New Mexico Tech in Socorro, and the University of New Mexico in Albuquerque as part of the project. Rango and his colleagues have spent 30 years predicting snowmelt runoff levels with a computer model he developed in the late 1970s and has been upgrading ever since. His Snowmelt Runoff Model (SRM) uses climate-change algorithms, imagery of snowpacks from National Aeronautics and Space Administration satellites, and data from ground-based SNOTEL sensors in 11 western states to measure water levels. Information is transmitted to relay stations and posted by USDA's Natural Resources Conservation Service (NRCS) online at *www.id.nrcs.usda.gov/snow/siteinfo/typical_snotel.html.*

Rango and his team will install five new gauges in the NRCS SNOTEL sensor network and upgrade 12 others, all in New Mexico, to improve runoff forecasts from snowpack. Rango's research should help farmers decide which crops to plant and when to plant them. It will also help public officials decide how reservoirs should be operated, whether reservoir water should be stored or released, how much water should be used to generate electrical power, how flood-control measures can be implemented, and how much water should be reserved to save endangered species.

"Change in timing and quantity of runoff is something water-management agencies need to know. They don't know what the effects on the water resources will be, and they need to know because water-management policies may have to change," Rango says.

Tracking water on small parcels

In Arizona, Doug Hunsaker is using an assortment of remote-sensing technologies – sensors mounted on tractors or planted in the soil, along with an unmanned aerial vehicle and an occasional helicopter flight – to find ways of conserving water by estimating crop needs at specific sections within fields, rather than assuming those needs are the same in all sections of the field.

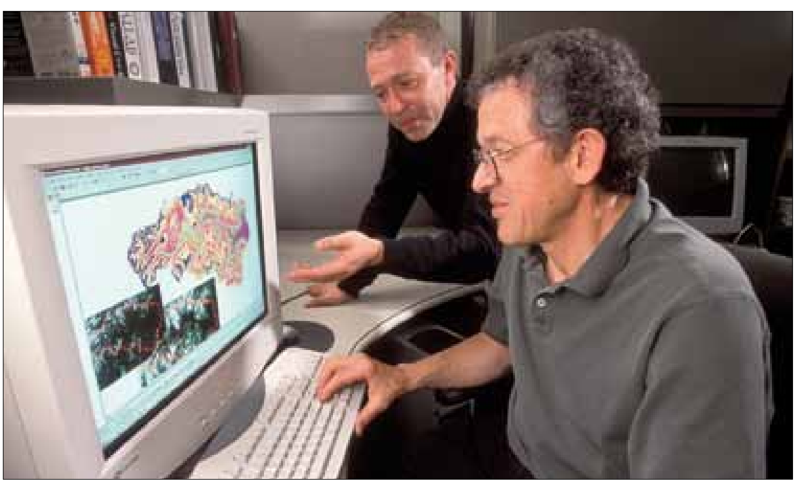
Hunsaker is testing a tractor-mounted visible and near-infrared sensor on small fields of cotton and wheat. The sensors, initially designed to detect nitrogen levels in soils, use red and near-infrared signals to estimate evapotranspiration – the amount of water transpired from a plant plus that evaporated from the soil. The sensors take readings as the tractor goes up and down the field during cultivation. They look and work like small cameras and are equipped with a global positioning system so they can give a precise reading of the location where the data was collected.

In Hunsaker's system, data on soil moisture levels and water use by plants – collected from the tractor-mounted and ground-based sensors – would ultimately be tied into data beamed from satellites.

Hunsaker is also using remote-sensing data collected from an unmanned aircraft – on loan from the University of Arizona – that provides additional information on crop water use as it flies over a field. Helicopter flights, made once every two weeks as part of Hunsaker's fieldwork, also provide complete remote sensing images of the entire field. Data collected by the helicopter flights is a proxy for information that will one day be collected by satellites.

"As technology improves, satellites will be able to do what we now do with helicopters so that farmers will be using satellite imagery to determine water needs," Hunsaker says. He has used the technology to study the water needs of camelina and lesquerella, two oilseed crops, but has focused mostly on small fields of cotton and wheat. He is currently testing the technology's effectiveness at determining actual soil moisture levels and growth rates in a 12-acre cotton field, divided into 16 plots, and he plans tests in a wheat field of comparable size in 2010.

Farmers are already using remote sensing technol-



Hydrologist Al Rango (foreground) and former postdoctoral research associate Enrique Gomez-Landesa evaluate output from predictive models of water runoff into the Upper Rio Grande basin.

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ogy to monitor crops and field conditions, but the goal is a new system capable of collecting data that farmers can use to determine daily water needs of smaller field sections. Ideally, farmers could identify areas with low or high water needs and, using either a drip or a sprinkler system, adjust irrigation levels based on the data.

Hunsaker compares the system to keeping a chequebook of each plant's water needs. "There's a reservoir of water in the soil. Each day it's depleted by the plant, and we're keeping track of that. Once the water amount reaches a certain threshold, we know it's time to water, and we know how much it needs. We're able to monitor with a kind of a 'chequebook' approach," he says.

The research is part of Pasture, Forage, and Range Land Systems (#215) and Water Availability and Watershed Management (#211), two ARS programs described on the World Wide Web at www.nps.ars.usda.gov.

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LEFT: View of cotton field from helicopter showing reflectance tarps used in calibrating multispectral imagery equipment.