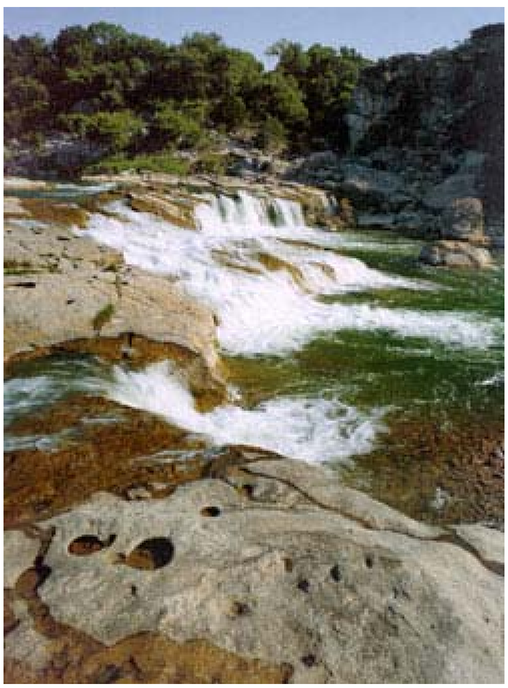
The University of Texas Press

Edge of the Desert

Scientists seek sustainable water supply for a thirsty world

Around the world, water supplies are threatened. The discovery of drugs in public drinking water is just the latest crisis in the United States. From California to Columbia, a larger problem looms—the ongoing availability of the resource itself.

Industrial agriculture places heavy demands on global water supplies. Energy production is another drain, threatening to tap out an already stressed resource. Meanwhile, world population is expected to grow from six to nine billion by mid-century. Add it all up, and the world appears to be facing an unsustainable thirst for water.



Pedernales River in Texas. Photo courtesy Texas Water Development Board.

Researchers at The University of Texas at Austin are at the forefront of scientific efforts to ensure a sustainable global water supply, examining water use for energy, agriculture and population growth.

University researchers benefit from the geography of the state itself. Situated on the southern edge of the Great Plains—a semi-arid region sometimes described as the "American desert"—Texas is similar to many of the world's population centers. As a result, the state offers an especially relevant natural laboratory for studying the types of water challenges that plague communities worldwide.

Water for Growth

Population growth is already leaving its water mark on Texas, points out David Maidment, director of the university's Center for Research in Water Resources.

"When I moved to Texas in 1980, the population here was 14 million," Maidment says. "It is now 24 million. We added 10 million people on a fixed water resource, and inevitably we are slowly evolving to a greater degree of vulnerability to shortages in water supply."

What Maidment fears most, he says, is a drought—not just any drought, but a "drought of record," like the decade-long drought central Texas experienced from the late 1940s through the late 1950s. It is the drought by which scientists now measure all droughts in Texas. River levels dropped dramatically. Streams dried up.

"If ever that happened again here, the degree of concern and disruption to the life of Texas would be quite profound," Maidment says.

Maidment has seen the effects of such a drought firsthand, not in 1950s Texas but halfway around the world in present-day Australia during a visit in November 2006. An extensive drought in Australia is causing nationwide despair, he says, with entire towns running out of water.

Maidment also saw similar despair in Corpus Christi in 1984, when a major drought resulted in the city having only 300 days left of water supply.

"So they faced the prospect that in 1985, the city of Corpus Christi would have no water and that caused a large panic which led to a loss of confidence in the leadership of the city and to a lack of confidence in the level of technical advice they were receiving," Maidment says.

The city would recover, but seeing the effects of the drought on Corpus Christi gave Maidment a mission: to help make sure that a community's citizenry is as informed as possible about its own water supply. For the past 20 years, he has been working toward that by building digital maps of Texas' surface and groundwater resources. Surface water comes from streams, rivers and lakes, while groundwater comes from underground natural reservoirs of water called aquifers.

In the late 1990s, the state's leadership, including then Governor George W. Bush, started asking basic questions about the state's water supply, Maidment says, such as: How much water does Texas have? How much does the state need? Scientists and policymakers were not able to address these questions adequately, leading to the state senate passing legislation in 1997 that required Texas to digitize all its water maps and get a handle on water management.

That was when Maidment was able to step in with his geographic information systems (GIS) and hydrology expertise. He and Ralph Wurbs at Texas A&M University had been leading research for years on surface and groundwater mapping and modeling. Now, 10 years after the legislation passed, the GIS products are coming out—helping to tell policymakers and citizens alike where their water resources are located and how much they have.

"We now have water availability models," Maidment says, "and a letter has been sent to every water permit holder in the state explaining how secure their water availability is in the event of a drought."


Bridget Scanlon.

But Maidment's work is not stopping there. He is working with CUASHI (Consortium of Universities for the Advancement of Hydrologic Science), a National Science Foundation-funded organization of university researchers, to make water maps and models even more accessible to the public. He wants to expand on methods used elsewhere in the country to help Texas further manage its water resources, hoping to eventually have a water availability map as easy to use as Travelocity, for example, he says.

All of this work, Maidment says, will at a minimum, mitigate the political and social ramifications of a drought.

"What we owe to our citizens is that they should feel their universities and their state are on top of the problem and are conveying the magnitude of the issues," he says.

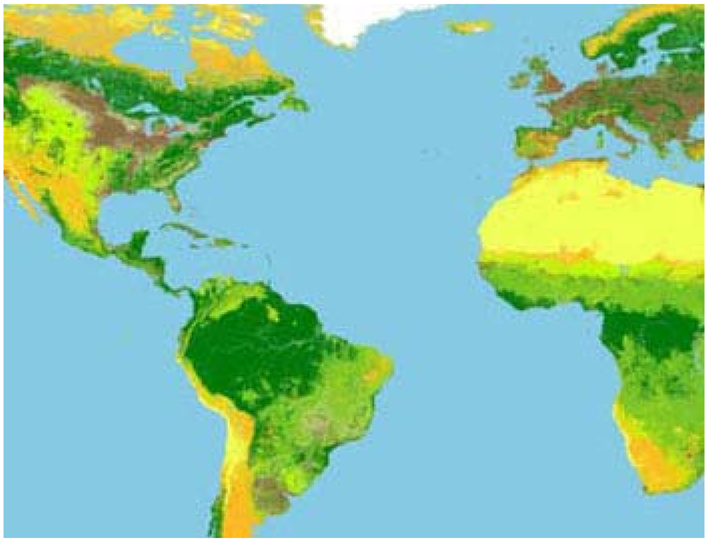
Water for Food

When Bridget Scanlon thinks of water, she thinks of food and how vital water is to crop production. A senior scientist at the Jackson School's Bureau of Economic Geology, Scanlon first became interested in water to learn about helping feed the poor of Africa. She has not made it to Africa yet, but she is making great strides in understanding the processes at work there through her research in Texas.

For Scanlon, agriculture is the key issue when it comes to discussions of water demand: Globally, agriculture consumes 90 percent of freshwater resources.

"We need to get a handle on the water used in food production in order to manage water resources effectively," Scanlon says.

And Scanlon's work has been aiming to do just that. She and her colleagues have been looking at the impacts of land use on water in the Texas High Plains, which is one of the largest agricultural areas in the United States. Her work covers a lot of ground, from looking at various agricultural practices to examining flow patterns in the High Plains aquifer, which covers parts of South Dakota, Nebraska, Wyoming, Colorado, Kansas, Oklahoma, New Mexico and Texas.



How will the world handle increased croplands? Global cropland for food production is projected to expand this decade. Scanlon's research shows that if the new cropland is primarily irrigated, it will stress water supplies and water quality, whereas rain-fed croplands could enhance recharge.

View complete image of global distribution of land cover (opens in a new window).

Most recently, Scanlon published a paper in the journal *Water Resources Research* about the effects of converting natural rangeland to cropland. Some of what her research group found was surprising, for example that converting from grasslands to cropland actually increases how quickly groundwater can be replenished in the aquifer. Converting to agriculture in many parts of the world, including Australia and Africa, as well as Texas, has thus caused groundwater levels to rise. Scientists previously had not recognized such a positive benefit of agriculture, Scanlon says.

Perhaps the biggest consideration for agricultural practices, however, is irrigation.

"Any type of irrigated agriculture is basically not sustainable," she says.

For example, even in the High Plains, where irrigated agriculture occupies only 11 percent of the land surface, it greatly depletes groundwater resources. From 1950 to 2003, the average groundwater level declined throughout the High Plains about four meters, and the average decline was as high as 12 meters in the Texas section of the High Plains. Irrigation is basically mining the resource, using it faster than it can be replenished.

Solving the problem of irrigation is complex, however, as deficit irrigation results in salinization of soil. When crops use water, they leave salts behind. With enough watering through irrigation, the salts get flushed out, but relying only on rainfall, the soils became inundated with salt.

The solution, Scanlon suggests, is rotating between rain-fed and irrigated agriculture, where "you let the water levels rise to a certain extent, then you have a period of irrigation, and then you move back to nonirrigated rain-fed agriculture."

Other options people are considering include rainwater harvesting and planting crops more in season with natural climate variability.

Despite these challenges, however, Scanlon remains optimistic.

"For agricultural water management, there's a lot we can do," she says. "Even changing tillage, you can really change the water cycles in that system."

Scanlon continues to work toward understanding the various impacts people can have on agricultural water management, and hopes to eventually transfer what she has learned in Texas all the way to Africa.

Protecting the nation's soil, water and air resources is a key part of the mission of the Agricultural Research Service (ARS). Since, globally, irrigation for growing food is one of the biggest users of fresh water, ARS scientists are developing high-tech farming systems that will conserve both water and fertilizer. **Photo by Jack Dykinga, USDA**.

Water for Energy

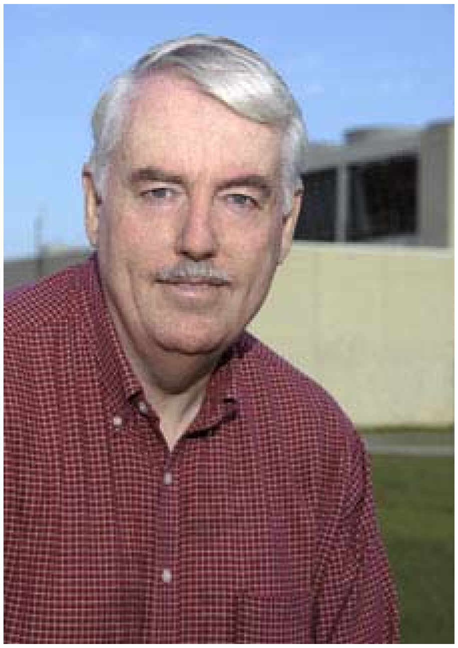
Agriculture accounts for more freshwater consumption than any other human activity—90 percent of all fresh water humans consume globally and 80 percent in the United States. Energy consumes less, because water used for energy is often returned to the water system. Yet energy is the largest withdrawer of freshwater in the United States, accounting for nearly half of all freshwater withdrawals.

"Every time we leave a light on in the room, we're using electricity and that electricity uses water," says Ian Duncan, associate director for earth and environmental systems at the Jackson School of Geosciences' Bureau of Economic Geology.

This less-publicized use of water is a major challenge to sustainability. The same population pressures that could push the water demand to extremes in the next 25 to 50 years will also create greater energy demands.

To better understand this issue, Duncan has just received a grant from the Texas Water Development Board. He wants to find some more sustainable, viable options for electricity generation that use less water.

The majority of electricity in the United States comes from thermoelectric power. Power plants either burn coal or use uranium fission to boil water and make steam that turns a turbine and creates electricity.


Ian Duncan.

"We end up having to use water not just in the steam but also to condense the steam, and cool the steam down," Duncan says.

The lakes of water right next to power plants are the sources of water being tied up to cool the steam. Although much water is returned to the lakes after its use in the plants—hence not contributing to higher consumption numbers—that water is not being used for drinking or growing crops, Duncan says.

One alternative to this water-heavy process is to use air, not water, to cool the water being used as steam in the power plants, Duncan says. Using technology similar to what is found in a typical air conditioner, such a system could save large amounts of water—using 5 to 7 percent less water than traditional thermoelectric plants.

One problem with air-cooling is that it works better in cold, dry areas than warm, moist areas. Duncan is going to be calculating which parts of Texas would benefit from dry cooling and whether that could be implemented to free up water resources for other demands.

Another solution involves desalination, says J.P. Nicot, a colleague of Duncan's at the Bureau of Economic Geology. Texas cities San Antonio, El Paso and Lubbock are all moving toward desalinating slightly salty groundwater to address their rising water demands and dwindling freshwater supply. Duncan says desalination uses quite a lot of electric power, which of course uses more water. Such a route, he says, is likely not sustainable in the long term.

Nicot, however, says one solution would be to locate desalination plants with energy plants. That way, the water being used to cool the steam for thermoelectric power generation could be desalinated and used for other purposes, such as drinking water and agriculture. Regions of the Middle East already employ such a technique—building power plants close to desalination plants so the water can serve dual-use.

Water for Living

In addition to the many water demand challenges, including agricultural and energy consumption, society will continue to face challenges related to finding enough clean water. Particularly in developing countries, water quality is a bigger issue than water quantity, but the issues are intimately connected, says Jay Banner, director of the university's Environmental Science Institute and co-professor of the university signature course, "Sustaining a Planet."

Society needs to be prepared to deal with water issues in an integrated way.

Coal power plant in Datteln, Germany, at the Dortmund-Ems-Kanal. **Image by Arnold Paul**.

"We're going to need more crops to feed more people," Banner says. "we're going to need more places for people to live. The cities will grow outward and continue to sprawl and change the way landscapes look and the way we use landscapes."

As scientists strive to understand the various impacts of the way people use water, they will continue to inform policy decisions from the local level on up. Banner is focusing on training the next generation of environmental scientists at the Jackson School—hoping to instill in them the interdisciplinary nature of the studies that Scanlon, Duncan, Nicot, Maidment and others undertake.

"In order to be able to solve these water problems, we can't just do one type of water science," he says. "We need to have as broad a perspective as possible."

But it is not only scientists and policymakers who can make a difference when it comes to changing the global water picture. Changes in diet and personal practices can have dramatic impacts on water resources. Changing from a nonvegetarian diet to a vegetarian diet could save up to thousands of liters of water consumption per day per person, points out Scanlon, because of the quantities of water required for livestock.

After changing agricultural practices, "the way that we could probably save the most water is through changing our individual habits," says Duncan, such as turning off the faucet while brushing teeth, using low-flush toilets and planting trees that use less water.

Duncan grew up on the edge of the desert, in New South Wales, Australia, where years would pass without rain. His family had to rely on artesian water—hot and salty groundwater—until rain would fall and collect in a tank on the roof of his family's house.

His family members in New South Wales continue to conserve water in small and large ways that may surprise Texans and others.

"My mother does things like if she turns the hot water on and it's cold initially," Duncan says, "she puts a bucket under there and she collects all the water and she uses that for other purposes. There are a lot of things we can do as individuals to conserve water."

By Lisa M. Pinsker

Related Sites:

- **Center for Research in Water Resources**
- **Bureau of Economic Geology**
- **Environmental Science Institute**
- **Jackson School of Geosciences**
- **Research** at The University of Texas at Austin

Related Stories:

- **One Year After Solomon Islands Disaster, Scientists Realize Geological Barrier to Earthquakes Weaker than Expected** - 2 April 2008

Office of Public Affairs
P.O. Box Z
Austin, Texas
78713-7509

512-471-3151
Fax 512-471-5812