Like deserts? Expect to see more of them as the West heats up, says one Scripps researcher

BY ROBERT MONROE

Hugo Hidalgo considers the long-term influence of the Pacific Ocean on aridity patterns in the western United States.

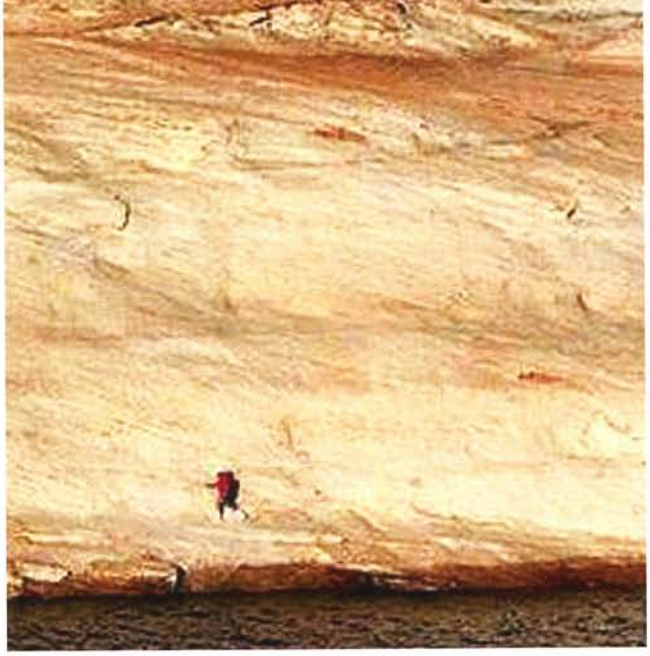
THE AMERICAN WEST: 2050

THE AMERICAN DESERT EXISTS in our imagination as a shaper of character, of frontier spirit and survival in the face of adversity. It conjures up images of a hardscrabble Old West inhabited by cowboys and covered wagons.

Now a new counterintuitive look at drought and desertification by Hugo Hidalgo, a hydrologist in Scripps Institution of Oceanography's Climate Research Division, suggests that we air-conditioned members of the "New West" might need to come to terms with the desert. If the average warming expected from widely accepted climate change scenarios is accurate, his analysis suggests that the arid areas of the American West can be expected to grow by nearly 20 percent. The wet areas, such as the mountains that store most of our water supply, are likely to shrink by a proportionate amount.

"I'm hoping to increase awareness of the magnitude of these changes," said Hidalgo, who first became interested in hydrology as an undergraduate student in his native Costa Rica.

Many scientists have interpreted the potential impacts of climate change predictions for the twenty-first century

on western water supplies. What has set Hidalgo apart is the flip-side approach to part of his analysis. While a large part of hydrologic research in the West has focused on a dwindling supply of water from the mountain snowpacks in coming decades, he has focused more on increases in demand, particularly considering effects on lowland deserts.

"Our understanding of demand is not up to the task of answering how much water we'll need in a changed climate," said U.S. Geological Survey hydrologist Mike Dettinger, one of Hidalgo's collaborators. "Nowhere near enough of this research is being done."

MAPPING A FUTURE OF UNKNOWNS

Even Hidalgo's approach to defining aridity runs against the grain. Most often dryness and drought are defined by comparing the amount of precipitation a given area gets to how much that area will be expected to dry out over the course of a year.

But that method wasn't sensitive enough to track the real interplays between snowy Decembers and broiling Julys.

So Hidalgo, the son of a meteorologist, compared actual and potential rates of evapotranspiration, the loss of moisture to the atmosphere from soil, plants, and bodies of water. The ratio between actual and potential evapotranspiration enabled him to create an index of evaporative efficiency that could track the effects of climate change through the seasons.

Under this definition of dryness, Hidalgo conducted a retrospective look at twentieth-century climate patterns and projected what could happen under various temperature-increase and precipitation-decrease scenarios. To paint a picture, he created a hydrologic map of the western states.

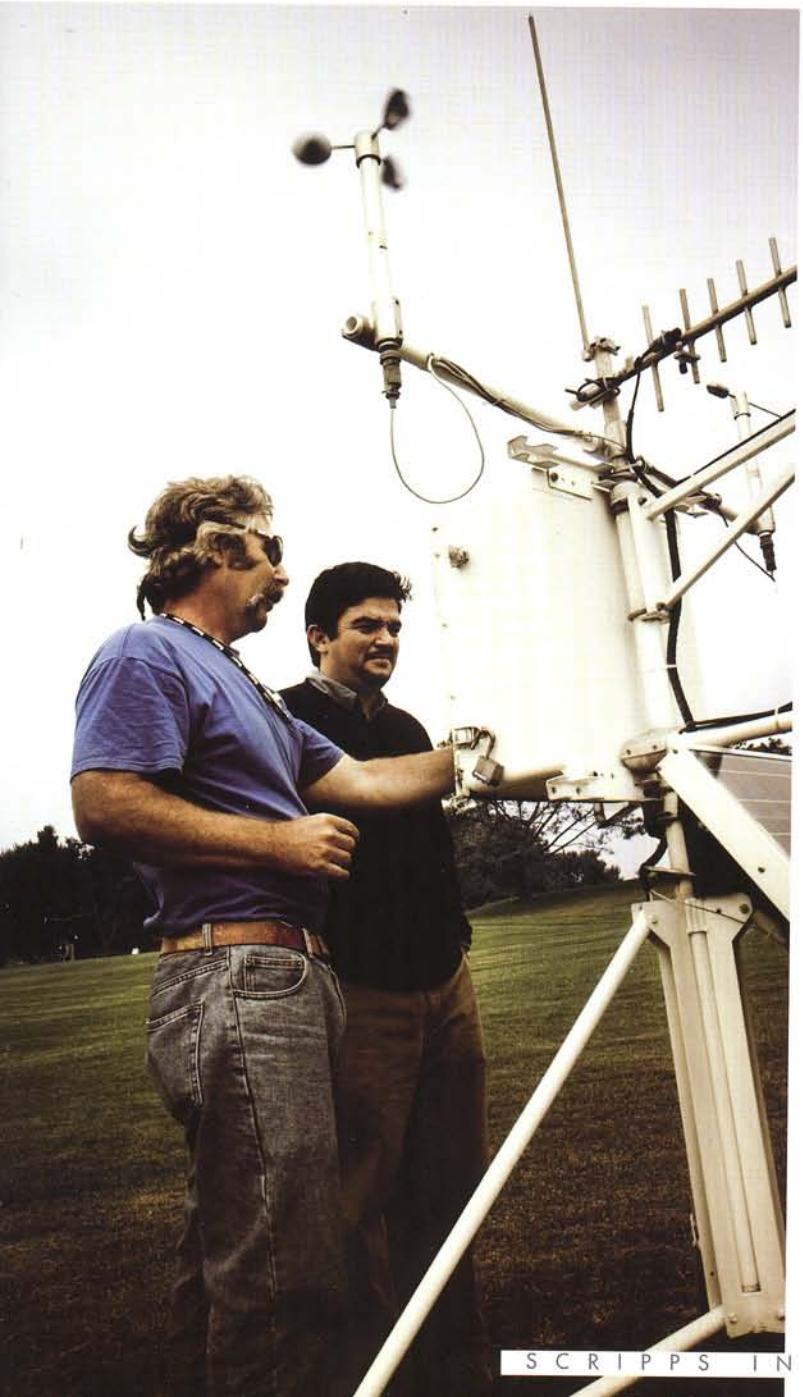
The map is broken down into "energy-limited" regions, places like snowy mountaintops that never really dry out even during summer months. There, the meager energy supplies of wind, heat, and light are tapped out before the water is all evaporated.

Hidalgo calls deserts and other dry places "water-limited" regions, areas where the supply of water from the ground and plants will be exhausted before the limits of nature's ability to dry them out is reached.

Between the two regions are the semiarid areas. They can go either way, becoming desert during droughts, being rejuvenated as forest or grassland in rainy years. Following extreme droughts, those places could need several years to come back if they come back at all. In normal years, many of these areas will switch from being energy-limited to water-limited and back again.

History has shown just how extreme sustained periods of below-average rainfall can be. Aridity was a defining characteristic of the West from the end of World War I to the beginning of World War II. This led to the Dust

Clockwise from lower left, *Scenes from a drought: a dry river basin in Arizona; felling trees killed by bark beetle infestation; a hiker on shores of Lake Powell once 100 feet underwater: long-parched Arizona ranchland; the confluence of Arizona's Salt River and Roosevelt Lake, 2002, with 1993 lake levels clearly visible.*



Above and left, *Hidalgo never had to leave his computer to perform his analysis of CIMIS data and water- demand trends. San Diego city water official Kevin Farrer gave Hidalgo his first up-close look at one of the CIMIS stations.*

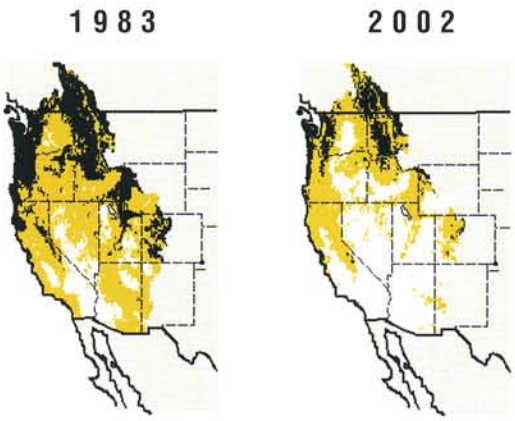
Bowl before eventually yielding to a new phase of a climatic shift scientists would only decades later know as the Pacific Decadal Oscillation.

Going further back in time through records left behind in tree rings, Hidalgo and other scientists have discovered even longer, more catastrophic droughts. A 30-year drought in the eighth century is cited as a main cause of the collapse of Mayan culture. In the late 1500s, a so-called megadrought lasting more than 40 years is believed to have contributed to the deaths of millions of native Americans, coinciding with a mid-century outbreak of hemorrhagic fever.

Today a drought of even five years can have devastating economic consequences. A much more heavily populated West and intensive agriculture require a steady water supply.

But while water delivery to a farmer or a city can be engineered, ecosystems do not have the same ability to manipulate their surroundings. Along with what Hidalgo projects would be an 18

Above, *One of the 125 active CIMIS stations in California is just a slice away from the tee box of the second hole at Torrey Pines South Golf Course.*



Above, *The American West, defined as points west of 100° longitude in Hidalgo's study, experienced two extremes in the El Niño year of 1983 (left) and 2002, one of the driest of the last century (right). Arid regions in white comprised only 10 percent of the West in the former year but jumped to 37 percent in the latter. "Energy-limited" areas in black and "water-limited" areas in yellow shrank between the two years by a corresponding amount.*

percent increase in desert, the coming years could be characterized by more frequent drought conditions and wholesale geographic shifts or even disappearances of many plants and animals that live in the West. With that change also comes an increased likelihood of catastrophic wildfires as entire stands of forest fail to adapt to a hotter climate.

"It's not really what we're used to or what we're prepared for," Dettinger said.

DEMAND HEATS UP

Hidalgo got the idea for looking at aridity in a new way during an earlier review of evapotranspiration rates. His 2005 research paper is one of only a few to consider the future of California's water demand rather than supply against a backdrop of rising temperature. His study analyzed more than a decade's worth of data collected by a state Department of Water Resources-run program called CIMIS, the California Irrigation Management Information System. The program has been in existence since 1982 to serve the state's $26-billion agriculture industry and other major users of water.

The program operates a network of autonomous meteorological stations across the state, not just at farms but in parks, golf courses, military facilities, and other places with expanses of ground vegetation. The network, now with 125 active stations, makes available to farmers and other water users data such as air temperature, humidity, and wind speed that help them determine their water needs from day to day.

In the analysis of CIMIS data, Hidalgo found that cloud cover actually matters more than heat in influencing evaportranspiration rates, especially in spring when counteracting trends of precipitation and potential evapotranspiration most commonly overlap. He used the data to consider what projected climate-change trends will do to demand for water in California. He estimated that a 3°C (5.4° F) increase would raise demand by roughly six percent. Though the projection could only loosely account for certain variables, the work was enough to get the

attention of state officials.

"Demand is certainly half the balance," said Maury Roos, chief hydrologist for the Department of Water Resources and an advocate of improving the state's water infrastructure. "Hugo is starting to look ahead a bit and that's important."

DOUBLE WHAMMY

As the West continues along a likely trend of warming, it's difficult to know which backdrop is more unsettling: On one hand, human-caused climate changes over the past 50 years appear to be behind trends such as earlier snowmelt in spring and a greater proportion of precipitation falling as rain instead of snow. Both trends diminish the ability of California's main water supply, the Sierra Nevada, to release its stores in a controllable way, and neither trend bodes well, especially as population growth increases demand for water. On the other hand, nature has shown itself capable throughout history of creating even more profound water-supply problems in the form of catastrophic drought.

Above, *Hidalgo's research complements Sierra Nevada spring onset studies conducted by Scripps's Dan Cayan and former student Jessica Lundquist, here measuring streamflow in a 2003 field project.*

Because of the difficulty of pegging climate trends solely on nature or human activities, the year 2002 sticks out as an important one in Hidalgo's analysis. By his definition of aridity, that year was the driest to hit western states in nearly a century. Some 35 percent of the West was counted as arid, by Hidalgo's measures. By comparison, in 1983, when El Niño held sway in the West, only 10 percent was considered desert. Now Hidalgo is trying to understand what forces made 2002 so dry. Although it's difficult to find the ultimate causes of drought, it could be that the dry spell is a response of the combination of natural cycles and anthropogenic global warming. Megadroughts traced through tree-ring data that are associated with natural variability are still of grave concern for the West. It is expected, however, that climate change would worsen these naturally occurring severe and sustained droughts in ways that we are just beginning to understand.

"We should be very concerned about the results from the addition of these natural variations to human-induced trends," Hidalgo said.