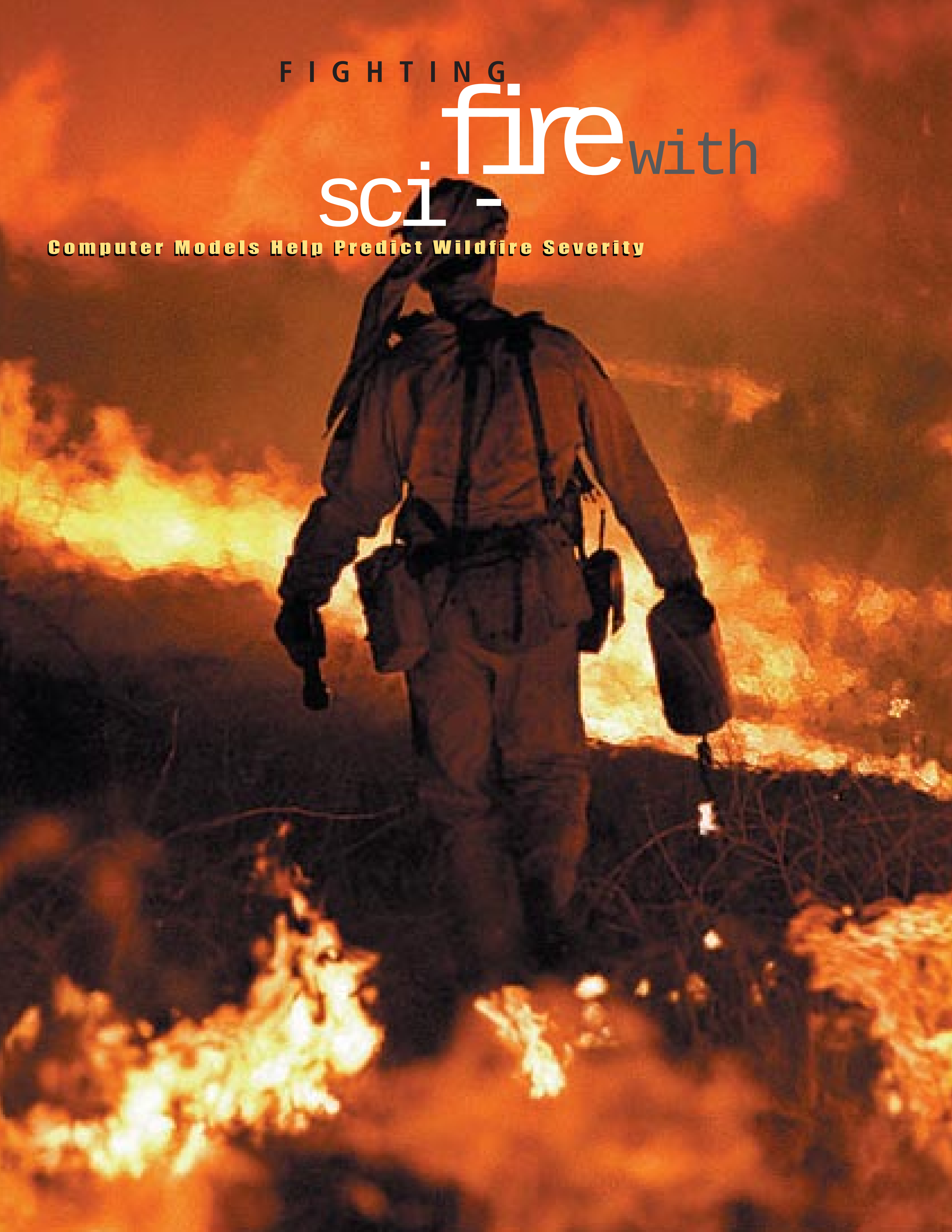
FIGHTING fire with sci -

Computer Models Help Predict Wildfire Severity



By ROBERT MONROE

Above, *John Roads at a U.S. Forest Service communications center amid emergency operators, who are among the potential beneficiaries of his fire weather forecasts.* **Opposite page,** *A firefighter sets a backfire during a 1995 blaze in Jamul, a city of 6,000 in eastern San Diego County.*

THE 2000 FIRE SEASON wasn't the worst in U.S. history, but for scores of fire officials and property owners across the country, it was bad enough.

A total of 90,000 wildfires cost taxpayers $1.6 billion to fight. They burned 7.3-million acres and destroyed 900 structures. Even some prescribed fires were nightmares. A National Park Service controlled burn near Los Alamos, New Mexico, in May turned wild hours after being set, burning 47,000 acres and destroying more than 200 homes. Officials were later blamed for mishandling National Weather Service wind warnings and not having enough contingency firefighters on hand.

Ironically, the 2000 season provided the perfect prelude for a fire-forecasting model developed by Scripps climatologist Anthony Westerling. Though it might take years for the model to earn widespread acceptance, it garnered significant interest among federal firefighting officials looking for ways to improve strategy. It has become the second forecasting tool from Scripps to build a following. John Roads has spent the past 10 years developing a different kind of model in a growing partnership with the U.S. Forest Service.

STATISTICALLY SIGNIFICANT SCIENCE

Westerling occupies a rare niche among Scripps scientists. Although surrounded by chemists and biologists, he earned his Ph.D. in economics. This background could turn out to be crucial to the success of his model, which takes a new approach to analyzing the drought data that have been used for years in fire management. His model's potential value in influencing how firefighting dollars are spent and how manpower is allocated has brought it to the attention of key firefighting officials and

policy makers.

"I'm interested in the societal impacts of climate variability," Westerling said. "A lot of issues deal with how we manage the environment in federal lands."

Westerling received his doctorate from the University of California, San Diego in 2000. He wanted to put his interest in environmental policy, as well as his economics degree, to good use and as a result came to Scripps, where he ultimately began working with Dan Cayan, director of the Climate Research Division (CRD).

"I'm interested in the societal impacts of climate variability."

—Anthony Westerling

Cayan also heads up the California Applications Program, a National Oceanic and Atmospheric Administration (NOAA) sponsored effort that has funded much of Westerling's work. With Cayan's encouragement, Westerling set out on an econometric mission to apply statistical principles to real-world conditions—in this case, fire hazards. Completed in March 2000, his first fire forecast was a preliminary estimate of the fire season to come as expressed by the number of acres that could be expected to burn in an area. Westerling's information came from two sources: data from firefighting agencies about previous fires in a given area and data about the amount of available "fuel" for fires.

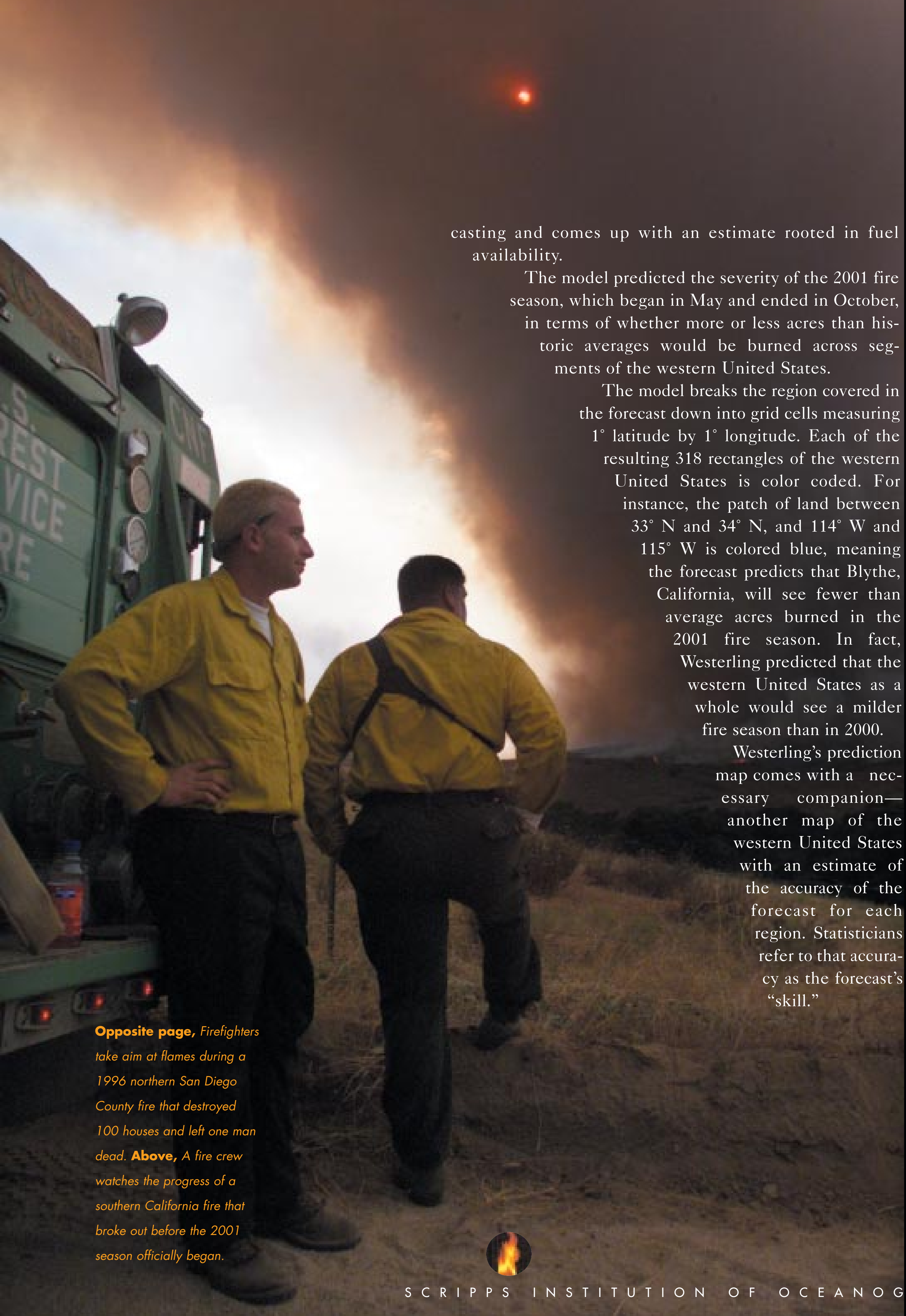
Arguably Westerling's biggest accomplishment to date is his collection of reams of fire data gathered by federal agencies, including the U.S. Forest Service, the Bureau of Land Management, the Bureau of Indian Affairs, and the National Park Service. These agencies record the dates, sizes, and locations of fire incidents within their jurisdictions. Rarely, Westerling found, has information from such agencies been combined for a comprehensive survey of climate–fire interactions.

Records from all of these agencies are fed into Westerling's computer model. Most of the ingredients are physical measurements called the Palmer Drought Severity Index. The index considers how much moisture has accumulated in the soil of a wilderness, how much rain the region has received, and, if the region is enduring drought, how long the drought has lasted.

NOAA and other government agencies have used the index as a hydrologic diagnostic and predictive tool since the 1960s because of what it reveals about the natural fuels that can start fires. A wet year means that an area might have an abundance of grass. A more arid year means that the grass is dry and liable to catch fire.

The index is not without faults. It doesn't measure snowfall in higher elevations very accurately, for instance. But for Westerling, the data package provides a convenient summary of long-term climatological averages in various areas of the country.

Westerling's model utilizes index data for the 24 months preceding the time period he is fore-



Opposite page, *Firefighters take aim at flames during a 1996 northern San Diego County fire that destroyed 100 houses and left one man dead.* **Above,** *A fire crew watches the progress of a southern California fire that broke out before the 2001 season officially began.*

casting and comes up with an estimate rooted in fuel availability.

The model predicted the severity of the 2001 fire season, which began in May and ended in October, in terms of whether more or less acres than historic averages would be burned across segments of the western United States.

The model breaks the region covered in the forecast down into grid cells measuring 1° latitude by 1° longitude. Each of the resulting 318 rectangles of the western United States is color coded. For instance, the patch of land between 33° N and 34° N, and 114° W and 115° W is colored blue, meaning the forecast predicts that Blythe, California, will see fewer than average acres burned in the 2001 fire season. In fact, Westerling predicted that the western United States as a whole would see a milder fire season than in 2000.

Westerling's prediction map comes with a necessary companion—another map of the western United States with an estimate of the accuracy of the forecast for each region. Statisticians refer to that accuracy as the forecast's "skill."

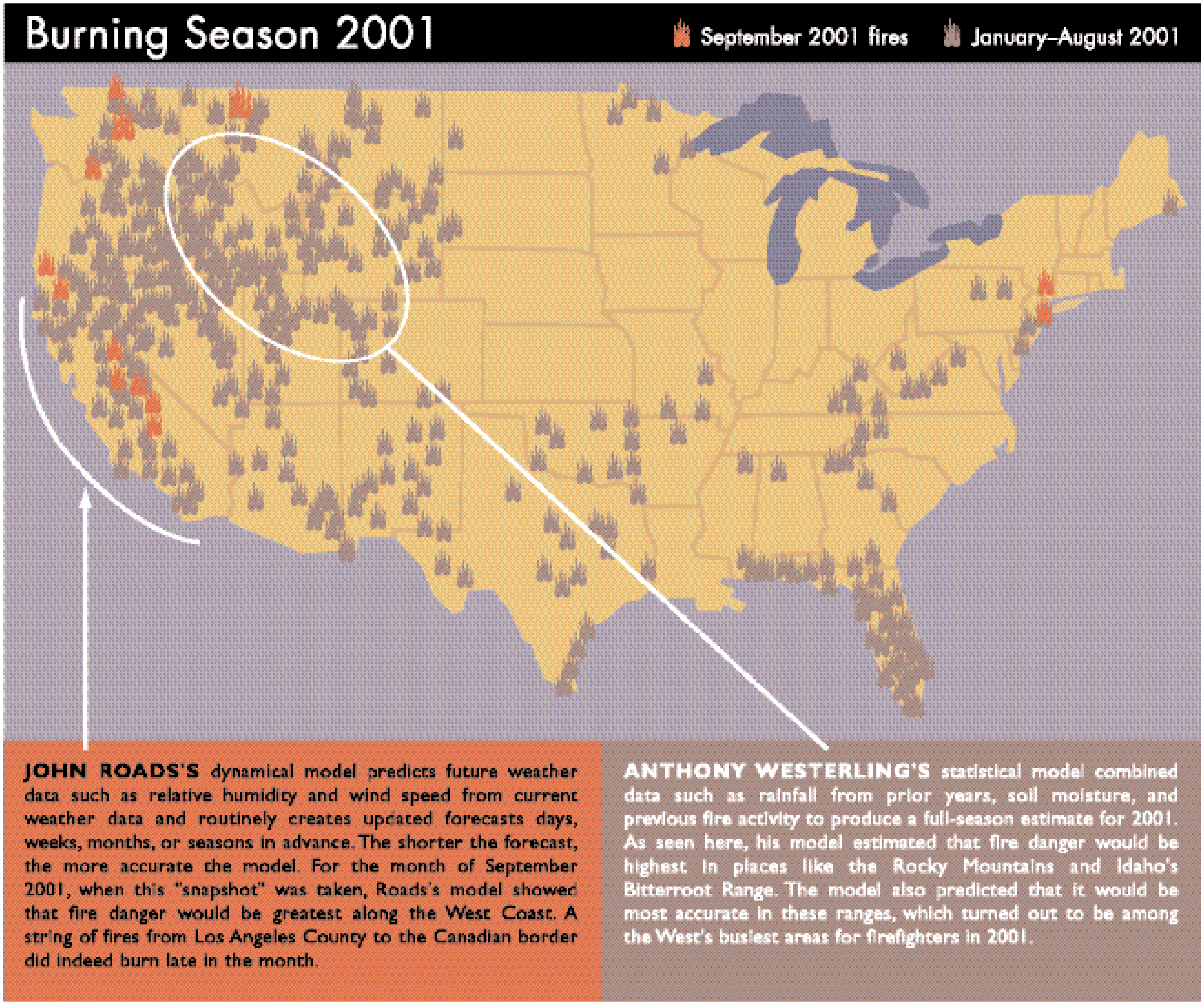
FROM CASINOS TO CLIMATE

The probability involved in creating statistical skill may seem like a trifle at first glance. Being right 51 percent of the time still means you're wrong 49 percent of the time. But in fact, these odds are still beneficial when it comes to making predictions. Just ask the casino industry, which sets the rules of games to give the house a small edge over gamblers and rakes in millions.

A model with predictive accuracy that is just better than 50-50 also helps propel the long-range forecasts being developed by John Roads. As director of the Experimental Climate Prediction Center (ECPC) at Scripps, he has been working with government agencies to develop forecasts from global and regional climate models in several different ways. With the U.S. Forest Service, he has been developing a Fire Weather Index over the past 10 years.

While Westerling's model involves only the Palmer index and its measure of fuel availability for fires, Roads is attempting to improve upon standard fire-danger predictions. Since the 1970s, the National Fire Danger Rating System has informed the public of the relative fire danger a day's weather conditions may bring. Motorists in national

Fuel availability, such as the dry trees being doused here in a 2001 fire near Alpine, California, is at the heart of Anthony Westerling's forecast model.



In the two prediction schemes developed at Scripps by John Roads and Anthony Westerling, different methods were used to predict fire danger for the 2001 fire season. Both researchers predicted a generally milder season than federal fire officials did, but said certain areas faced higher danger than others. The map shows active fires in late September and fires that took place earlier in the season.

forests will often see the rating posted outside ranger stations.

Roads wants to make seasonal predictions with as much skill as current daily predictions and is modifying his experimental climate models to output the basic variables needed for fire-danger indices. Unlike Westerling's statistically based model, Roads's model is a dynamic one; it relies on hydrodynamic and thermodynamic equations to predict weather and climate.

The National Weather Service uses such a model to determine how heavy the rain will be on any given day. Only recently have meteorologists begun to hazard much longer range seasonal forecasts.

Among Roads's challenges is to come up with enough computational power to handle the voluminous amounts of data needed not only for long-term forecasts but also for high-resolution predictions specific to localities. In an experiment taking place in Hawaii, for example, Roads hopes to create climate forecasts for areas as small as 2 kilometers (1.25 miles) across.

Above, *A water-dropping helicopter, a scarce resource in fire management, scores a hit during the 2001 fire season.*

Opposite page top, *The encroachment of homes into wilderness areas has made recent fire seasons more dangerous, which has led to more intense calls for changes in firefighting policy.* **Opposite page below,** *Anthony Westerling at the site of an August 2001 fire in Ramona, California.*

"We're finding ways to connect to the applications community, which always wants predictions at the local level," Roads said.

Even with low accuracy levels, these predictions can help fire managers decide where to send resources throughout a year, resulting in quicker responses to fires and cost savings.

The U.S. Forest Service is giving increasing credence to Roads's models, which officials can review on ECPC's Web site. But even though Roads envisions forecasters someday predicting fire danger several seasons in advance, the U.S. Forest Service is primarily interested in increasing the reliability of short-term forecasts.

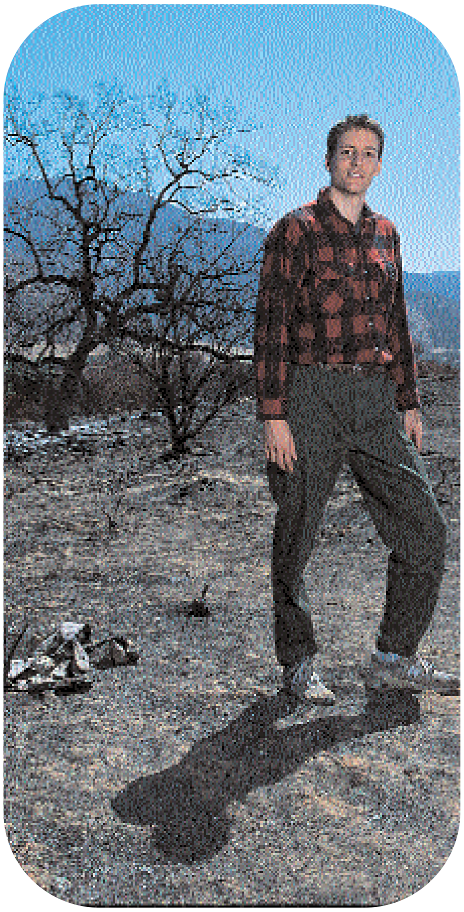
"We don't have a really good way of making predictions that extend for multiple years, so John and ECPC are helping us to get there," said Francis Fujioka, the U.S. Forest Service's project leader for fire meteorology at the Pacific Southwest Research Station in Riverside, California.

(For more information about the ECPC at Scripps and its prediction models, visit ecpc.ucsd.edu.)

WHEN PREDICTIONS BECOME HEADLINES

The summer of 2001 provided an important test of Westerling's and Roads's models, both of which predicted that the year would be far less hazardous than federal forecasters had reported.

Westerling's model was projected to be very accurate in certain parts of the western United States, but there are other areas of the country where the model's predictive ability was insignificant and its status in those areas may not ever be improved.



The Palmer Drought Severity Index that Westerling uses is a measure of how much vegetation is in a given area and how dry it is; in other words, how much fuel is available. In densely forested places such as coastal Oregon, the fuel necessary for catastrophic fires is always available but is kept from igniting by reliably soggy weather. Fire officials in an area like this have little use for Westerling's backward-looking model. They don't need it to tell them that several months without rain spells trouble.

In other regions, though, where fuel availability is less constant, Westerling's model shines. Areas such as the Mojave

Left, *A firefighter gears up before taking on a recent San Diego County fire.* **Opposite page,** *John Roads with a fire map.*

Desert in California or Utah's Great Basin, for example, could grow lots of grass one year but get no rainfall the next. The variability of available fuel is easy for the model to locate.

"One of the things that's very valuable to [fire officials] is knowing not only if it's going to be a bad year but when in the year it's going to be bad and where," Westerling said. "We think we can

IN THE MID-1950s while fighting a 17,000-acre forest fire in Lincoln National Forest, New Mexico, firefighters rescued a badly burned black bear cub from atop a charred tree. Nicknamed "Hotfoot," but soon known as Smokey Bear, he moved to the National Zoo in Washington, D.C., after his wounds healed.

For more than 50 years Smokey Bear served as an emblematic ambassador for the protection and care of natural resources by reminding the nation, "Only you can prevent forest fires!"

To learn how you can help protect the more than 700,000 acres of forest in the United States, visit fs.fed.us or smokeybear.com.

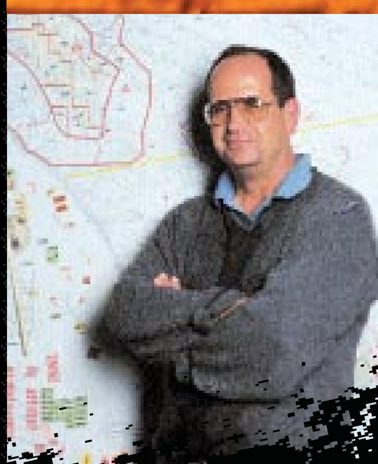
Even more than the maps of the fires themselves, the most important information along the walls of a Cleveland National Forest emergency center might be the roster of what equipment and which firefighters are available.

With firefighters constantly pressed into service to help with blazes outside their jurisdictions and equipment, such as aircraft shared by multiple agencies, wise allocation of resources is a must. The prediction schemes developed at Scripps—with refinements over time—promise to help officials make informed estimates of where and when future fire seasons will strike hardest.

predict the anomalies of the timing of the burning down to early season or late season."

Current federal forecasts rely equally on statistics and the judgment calls of veteran forest officials. Thus, they lack the empiricism of Westerling's computer model.

The summer of 2001 also provided what Cayan calls the model's "proof of concept," although the severity of an actual fire season is also determined by chance occurrences.



The model cannot, for example, account for how fast a particular fire crew douses a particular fire or where a cigarette might be thrown out the window of a car.

"Sometimes it may be that there's just not as much lightning as usual one year," Westerling said. "That might be one reason why we predict a fire season that never comes."

Likewise, only a track record of accuracy over time will gain widespread use for the Westerling and Roads models, but Fujioka is optimistic that prediction models like those being developed at Scripps will improve fire management significantly in years to come. ■