Will we ever control the ferocious forces unleashed by wildfires? Or can we learn to live with the natural cycle of burning and regrowth? To develop tools for coexisting with wildland fire, a research and development collaborative is tackling tough questions at the intersection of science and society.
Wildfires and people
Living with a force of nature

When record-breaking drought gripped much of the United States in 2002, wildfires started breaking records, too. Western fires with names like Biscuit, Hayman, and Rodeo-Chediski—the worst wildland blazes ever reported in Oregon, Colorado, and Arizona—became nightly news, along with smoke alerts for nearby towns and cities. Reports showed images of young men and women, their soot-streaked faces etched in fatigue, wielding hand tools as they labored to hem in the fires. With bulldozers and aircraft buzzing in the background, the shocked and worried faces of residents fleeing woodland homes also became a familiar sight.

“Fire’s been around forever,” says NCAR scientist Janice Coen. “What’s changed is that the confrontations between people and fire have become more severe and more expensive in recent years.”

For roughly a century, the chief method of U.S. forest fire management has been fire suppression, resulting in dense growth and piles of dead timber. Add prolonged drought, plus a spurt in development in western forests, and the recipe for conflict is complete.

Questions about the suppression policy have gradually increased over the past four decades. Meanwhile, researchers and forest managers have explored ways to manage forests as integrated ecosystems in which fire plays a vital role. New concepts, including increased use of prescribed burns, mechanical thinning, and other means to restore the health of overgrown forests, have been incorporated into a National Fire Plan (see “On the Web,” page 9). The proposals have their advocates and critics, and a debate is under way on how best to manage wildland fire in the next century.

Atmospheric scientists at NCAR and elsewhere are part of this dialogue. In 2001 they began building an international collaboration with fire scientists and land managers to create the next generation of fire management tools, from computer models that predict fire behavior to decision support systems that help communities plan for wildfires and mitigate their effects. To accelerate progress, the Wildland Fire Research and Development Collaboratory is bringing together scientists and managers who’ve competed in the past for research dollars and the attention of decision makers.

In a bad year, wildfire management costs the nation up to a billion dollars, says Steven Running of the University of Montana, “yet we’re not getting satisfactory decision making. This problem needs some new solutions, with different teams assembled to make progress, and the Wildland Fire Collaboratory is a way to do that.”

The effort to build a wildland fire program began at NCAR with researchers across several disciplines and divisions. It soon became apparent that a much broader approach was needed. According to NCAR’s Richard Wagoner, who brings years of program development experience to the task, “If you’re going...
After a fire, wildflowers and other new growth can take hold quickly.

A window on fire danger

Ecology professor Steven Running (University of Montana) and his team are looking to satellites to provide warnings on the flammability of vegetation, using data from the Moderate Resolution Imaging Spectrometer (MODIS) aboard Aqua, a satellite in NASA’s Earth Observing System. Running’s team is creating a worldwide evaporative index, updated weekly, that will identify areas where vegetation is dry and fire danger is elevated. “This work is in the research and development stage,” says Running, “but it’s part of the analysis of biophysics of the Earth’s surface that could improve fire-behavior modeling.”

Modeling the ferocity of fire weather

“What NCAR brings to the whole issue of fire science is state-of-the-art mesoscale meteorology,” says Running. It’s that regional- to local-scale weather, he notes, that drives fire behavior and makes it so dangerously unpredictable.

The NCAR coupled atmosphere-fire model was developed by Terry Clark, with Coen joining the effort in 1995. The model incorporates software from the U.S. Department of Agriculture Forest Service that factors in the local winds and the type and amount of fuel available to a fire. This changes the speed and direction of fire spread but doesn’t portray the effects the fire is having on the atmosphere—weather the fire itself creates. The NCAR model does that by feeding back into the atmosphere the heat and water vapor released by the fire, which in turn produce the intense horizontal winds and updrafts that drive the fire line.

Along with larger-scale weather, such as cold fronts, the model reproduces many of the fine-scale structures observed in explosive fires. NCAR research has demonstrated that “fire spreads in much more dynamic ways [than previously described], such as forward bursts of flame from the fire line—especially in crown fires,” says Coen. Understanding how these sudden, dangerous shifts occur at the local level and transferring this technology to field operations is a major goal of this work—one that could save firefighters’ lives.

Elsewhere in the collaboratory, Rodman Linn and colleagues at Los Alamos have a high-resolution atmosphere-fire model running on the lab’s supercomputer that depicts heat transfer and transport in detail. Michael Bradley’s team at Lawrence Livermore has used this model to study the 1991 Oakland Hills fire and other notable cases.

Models tailored for post-fire analysis are quite different from those geared toward minute-by-minute projections on a laptop in the field. The collaboratory hopes to advance both types of simulation. “We all acknowledge,” says Coen, “that there’s not going to be one model that suits all purposes.”

Coen adds that much more research is needed. How can we use new technologies to characterize the fuels available for wildfires? What flammable gases do different types of vegetation release in the heat of an approaching wildfire? What are the air quality impacts on local to global scales? Some researchers are working on seasonal predictions of fire risk, while others are investigating impacts of wildfire on the regional and global environment. For example, at NCAR Jean-François Lamarque is constructing a global model of carbon monoxide and David Schimel is examining the effects of wildfire on the carbon cycle—a key climate question, given carbon dioxide’s role as a greenhouse gas.

Poison or medicine for multiple ills?

The worst fears about prescribed fires were realized in May 2000 when a planned burn on about 900 acres of public land at the urban-wildland...
interface in Los Alamos, New Mexico, went terribly wrong. Close to 48,000 acres burned, damaging or destroying hundreds of homes, lapping at the edges of the Los Alamos National Laboratory, and wreaking about $1 billion in damage.

Post-fire investigators found serious problems with planning and procedures (see “On the Web,” below). A key goal of the collaboratory is to create decision support tools for land managers to help them determine when and where prescribed burns can be safely conducted and where other methods should be employed instead.

With prescribed burns, “We’re using a tool that already exists in nature,” says Justin Dombrowski, the wildland fire management officer for the Boulder (Colorado) Fire Department. Low-intensity fires consume overgrown clumps of trees and dead needles and branches littered on the ground. By opening up fire breaks and limiting the available fuel load, this thinning can prevent a more intense and dangerous crown fire from spreading across treetops. The ecological benefits are extensive, from improving wildlife habitat, native vegetation, and soil nutrition to reducing noxious weeds (although other unwanted plants could take hold after a fire).

For several years the NCAR team has gathered data at wildfires and prescribed burns across the western United States and Canada, using instruments from the ground or mounted on the NSF/NCAR C-130 aircraft. One instrument, a digital, high-resolution infrared imager, “sees” through smoke to produce color video images of hot, swirling air and flames, detailing their motion, size, structure, and temperature. Those data help improve and confirm the models.

**It takes a whole community**

Since 1997, the U.S. General Accounting Office has issued a series of reports calling for a move beyond broad goals to a more cohesive strategy to address the growing wildfire threat to forests and nearby communities. To help states and local communities assess their risks and devise prevention measures, Robert Harriss and Olga Wilhelmi of NCAR and Tim Spangler of UCAR’s Cooperative Program for Operational Meteorology, Education and Training are designing a computer-aided toolkit. The team will call on COMET’s experience developing distance education and training materials for the weather forecasting community as they work closely with at-risk rural populations to create the toolkit.

Wilhelmi is exploring the capabilities of GIS (geographic information systems) technology to visualize information on forest distribution, roads, homes, and other features. What happens, for example, if planners add a golf course here or a road there? How well would those firebreaks work under different weather conditions? The NCAR fire-behavior model will allow participants to play out scenarios and see the impact of virtual fires superimposed on their community’s landscape.

The National Fire Plan contains some controversial recommendations, including clearing vegetation within 600 feet (183 meters) of woodland homes and building perimeter roads to act as firebreaks. With the toolkit, community leaders and fire mitigation experts will be able to visualize the results of their planning.

As the collaboratory evolves, new output from laptops may join hand tools on the fire line. And despite what we’ve all learned from Smokey Bear, we may see more communities choosing to set small, prescribed burns more safely with the aid of computer models. Perhaps more communities at the edge of wildlands will develop land-use plans based on choices they’ve examined using visualization and discussion tools accessed over the Internet. And perhaps the choices themselves will look different once more is known about the volatile interactions of weather, wildfires, and people.

**On the Web**

Wildland Fire Research and Development Collaboratory  
http://www.rap.ucar.edu/projects/wfc

U.S. National Fire Plan 2001  
http://www.fireplan.gov

COMET computer-based training module: Fire Weather  
http://meted.ucar.edu/fire/fwx

Cerro Grande (Los Alamos) Prescribed Fire Investigation Report  
http://www.nps.gov/cerrogrande

What’s in all that smoke?

NCAR scientist Hans Friedli and colleagues are investigating toxic emissions from wildfires. For example, they’ve found significant amounts of mercury in laboratory burns and in research flights over wildfires. About half the atmospheric mercury got there from natural sources and the other half through human activity (such as smelters, incinerators, and coal-burning power plants). Forest vegetation acts as a sink, absorbing atmospheric mercury when it rains or falls out onto leaves or needles. During a wildfire, the stored mercury is released back into the atmosphere. This provides an additional source that can enter water-sheds, where interaction with microbes converts it into methyl mercury, a neurotoxin. Further studies to quantify wildfire emissions will aid in calculating mercury’s global sources and sinks. Also at NCAR, Alex Guenther, James Greenberg, and colleagues are focusing on emissions of flammable gases from vegetation in and near wildfires. They’re examining the impacts of these volatile organic compounds on the combustion process itself and on regional haze and pollution.