ECOLOGY

How Rain Pulses Drive Biome Growth

Most ecologists trying to picture how climate change will remold the world's ecosystems have been fixated on temperature. Piles of studies have predicted that as North America heats up a couple of degrees over the next century, the distributions of everything from oak forests to tundra may shift far to the north. But these ecological modelers haven't factored in the dramatic changes in storm frequency—and the droughts and heavier rains and snows those changes will bring to some regions—also predicted in a greenhouse world. Now, on page 481, researchers describe the first study to look at how swings in precipitation alter landscapes across an entire continent. This new research finds that some ecosystems respond much more strongly than others to pulses in rainfall, which can spur surprisingly dramatic bursts in plant growth.

Ecological bellwether? Grasslands like this one in Kansas are more responsive than other biomes to fluctuations in rainfall.

Scientists had suspected that fluctuations in rainfall could strongly affect productivity, says ecologist David Schimel of the Max Planck Institute for Biogeochemistry in Jena, Germany. "But it hadn't been confirmed, and it hadn't been quantified at the ecosystem scale." One of the first papers to synthesize data from a network of ecological sites set up by the National Science Foundation (NSF) 20 years ago, the study highlights the value of long-term data sets for understanding broad ecological patterns, adds Schimel: "It speaks to the importance of having these measurements made in the right place at the right time."

The amount of plant growth—or more precisely, productivity—of a patch of land is "the fuel on which ecosystems run," determining why deserts are so barren and rainforests so lush, notes Alan Knapp, an ecologist at Kansas State University in Manhattan. To explore how tightly precipitation drives productivity in different biomes, Knapp and co-worker Melinda Smith turned to NSF's Long Term Ecological Research (LTER) sites. At the 24 LTERs, researchers routinely track precipitation and what's known as "aboveground net primary production"—recorded by painstakingly measuring the growth of plants each year. Because measurements are taken in a consistent way at the various sites, the LTER network offers an unparalleled storehouse of data for comparing ecosystems, says Knapp. He and Smith drew on data spanning 6 to 23 years from 11 North American sites, including arctic tundra, grasslands and old fields, and eastern forests.

Some results were expected. Productivity was higher at sites with more average annual rainfall. And forests, with their relatively huge plants, had the highest production from year to year, with grasslands coming in second and deserts third.

But to their surprise, the duo found a different pattern in how these biomes responded to *fluctuations* in precipitation. Forests, which receive fairly stable amounts of annual rainfall, grow roughly the same amount in wet or dry years. Deserts, which were hit by the wildest swings in rainfall and thus could be expected to vary enormously in productivity, fluctuated only moderately. Instead, grasslands proved the most extreme, four times more variable than forests—a sizable difference. Grasslands may be so variable, the Kansas team surmises, because of their underlying growth potential: Compared to deserts, grasslands have more leaf area and can grow more densely. And compared to forests, grasslands receive and retain much less water, so they're less buffered against dry years.

Another unexpected result was that in all of the biomes, wet years had a much greater effect on plant growth than did dry spells. Knapp and Smith think that reflects plant properties that enable them both to resist drought and sprout new growth when well watered. Plant physiologists have noticed this resilience, Knapp says. "The question was, does it scale up to the ecosystem level?" he says. "We've shown that it does."

These new data should enable ecologists to improve their models of how biomes may respond to human-induced climate change, as well as to short-term patterns such as El Niño, says ecologist Ian Woodward of the

CREDITS: (LEFT TO RIGHT) ALAN K. KNAPP/KANSAS STATE UNIVERSITY; ADAM BUTLER/AP

ScienceScope

Vision Thing The National Eye Institute (NEI) is getting a new chief this spring: Paul Sieving, an expert in the genetics of macular degeneration.

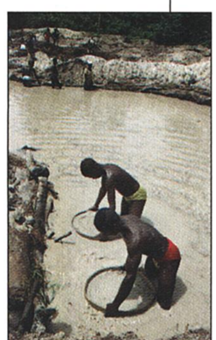
Sieving—who was recruited from the Kellogg Eye Center at the University of Michigan, Ann Arbor—has a broad record of academic achievement: an M.S. in physics from Yale (seasoned with a year of law school) and two degrees from the University of Illinois, an M.D. and a Ph.D. in biomedical engineering.

"I am honored to be joining the NEI" at a time of great scientific opportunities, Sieving said in a statement. "His experience as a senior administrator will be invaluable," says Ruth Kirschstein, acting director of the National Institutes of Health (NIH).

His appointment leaves just three unfilled vacancies in biomedicine's upper reaches: director of the NIH, director of NIH's AIDS office, and director of the National Institute of Neurological Disorders and Stroke.

Discerning Diamond Origins Wondering whether science can quell a threat to peace, the White House held a diamond summit last week to discuss how scientists might help identify gemstones that are fueling conflicts in Africa.

So-called conflict diamonds, which represent an estimated 4% of all diamonds sold annually, fund rebel forces in Sierra Leone, Angola, and the Democratic Republic of Congo. Once the gems enter the trade, however, their origins are difficult to discern. Researchers say spectroscopic and physical analyses might yield a unique signature that identifies a stone's origins, but the methods are untested and likely to be expensive, time consuming, and sometimes destructive to the jewels.



To get around such problems, a conflict diamond working group led by the White House Office of Science and Technology Policy (OSTP) will submit recommendations for future research to the National Science Foundation. NSF has not yet committed to funding the work, but outgoing OSTP technology chief Duncan Moore hopes to "move forward even this year."

Contributors: Wayne Kondro, David Malakoff, Eliot Marshall, John Davenport

University of Sheffield in the U.K. Knapp sees an additional value: Grasslands may serve as "early warning systems" that ecosystems are being altered by a changing climate—long before the trees migrate northward. –JOCELYN KAISER

ASTROPHYSICS

Microwave Telescope Data Ring True

Scientists listening for the faint hiss of radiation left over from the big bang have just gotten an earful. Data from a telescope in Chile designed to hear the cosmic background radiation are providing strong support for theories about how the universe evolved during the first few hundred thousand years after the big bang. The result—which shows a signal that other experiments have missed—is the first from the Cosmic Background Imager (CBI) and the beginning of what scientists say could be a banner year for cosmology.

"It's really an exciting time," says Scott Dodelson, a cosmologist at Fermi National Accelerator Laboratory in Batavia, Illinois. The CBI is catching the whispers of radiation born about 300,000 years after the big bang, when the universe was too hot for atoms to form. Light was constantly scattered in the monstrous plasma fireball, which reverberated with echoes of the great explosion. But as the universe cooled, electrons settled down with nuclei to form atoms. The opaque plasma became transparent, and the light that had been scattered and rescattered broke free.

That light, in the form of microwaves, now bombards Earth from all directions, allowing telescopes sensitive to that radiation to take pictures of the 300,000-year-old universe. Most recently, BOOMERANG, a balloon-borne experiment that circled the South Pole, made an exquisite map of the background radiation in a small region of the sky (*Science*, 28 April 2000, p. 595). But excited astronomers were puzzled when the data failed to show an expected pattern in the distribution of the radiation.

The early universe, scientists knew, rang like a bell after the big bang. Pressure waves rattled throughout the cosmos, causing variations in density that now show up as ripples in the amount of background radiation. And just as a bell's sound is made up of a fundamental frequency and a number of weaker higher-frequency overtones, the pressure waves in the universe had a "fundamental" of large-size peaks and dips in density and "overtones" of smaller and weaker peaks. BOOMERANG detected the fundamental's first peak but failed to detect the overtone second peak—as if theorists had predicted a bell but heard a horn instead. The missing second peak challenged observations of the amount of matter in the universe and threatened theories about how atomic nuclei formed. "It's a dilemma. The cosmic background is telling us one thing, but nucleosynthesis is telling us another," says Dodelson.

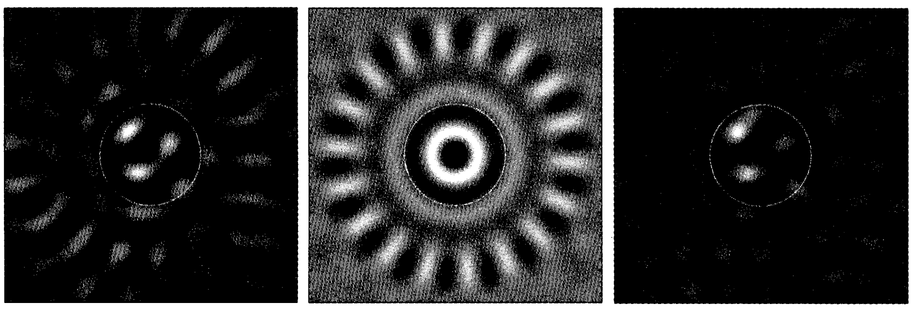
Now, to cosmologists' relief, the latest observations suggest that the second peak is there after all. "I think the discrepancy is real," says Anthony Readhead, an astronomer at the California Institute of Technology in Pasadena who was on the CBI team. "I don't think it is likely to go away."

Unlike the balloon experiments, which detect incoming radiation by converting it into heat, the CBI uses interferometry—detecting the phase and amplitude of incoming microwaves directly. Because interferometers have only recently become sensitive enough to measure cosmic background radiation, it's too early to say that the missing signal is definitely there, says Jeffrey Peterson, a cosmologist at Carnegie Mellon University in Pittsburgh. "But it takes a little of the sting out of the worries about the second peak."

However, Peterson says that another aspect of CBI's observations is worth celebrating now as support for an important theory about the acoustics of the early universe. The data show a drop-off in ripple size as the angular scale gets smaller and smaller, indicating that the overtones are weaker and weaker. "It's kind of exciting. It's the first time it's been seen in one experiment," Peterson says. "The acoustic oscillations in the early universe were dying away. It shows we're on the right track, that the acoustic model is right."

Readhead and his colleagues will publish their work in *Astrophysical Journal Letters*. Meanwhile, they are just beginning to analyze the flood of data from CBI. With more BOOMERANG results to come and other cosmic background experiments in sight, astronomers expect that the infant universe will soon snap into sharper-than-ever focus.

–CHARLES SEIFE



High fidelity. Raw microwave readings from the Cosmic Background Imager (left), minus instrument noise (center), reveal reverberations left over from the big bang.

SPACE STATION

U.S. Module to Offer Long-Term Lab Space

CAPE CANAVERAL, FLORIDA—Destiny has arrived for U.S. microgravity scientists. After 17 years of planning, dozens of reviews and redesigns, and billions of dollars, the U.S. scientific centerpiece of the international space station is ready to open its hatches for business. Called Destiny, the 8.5-meter-long aluminum vessel is scheduled for launch next month from Kennedy Space Center here. But putting the laboratory module into orbit—a 19 January launch was delayed 3 weeks due to electrical problems—is only the first step in a long and difficult road toward making the space station a scientifically credible venture.

About 120 researchers have already been chosen to conduct experiments in the lab. But the station's long-term value to U.S. commercial and academic researchers—nearly half the current portfolio is from industry—hinges on the ease of operations in space as well as on NASA's ability to fund, streamline, and provide a clear scientific direction for its troubled life and microgravity sciences effort. "This is going to be our Hubble" Space Telescope, says Kathie Olsen, NASA's chief scientist and acting life and microgravity sciences chief. "We need to get the community involved to do the right type of research."

With space station assembly expected to continue until 2006, the lab initially will look more like a construction site than a haven for research. But NASA managers say the module represents a quantum leap in doing science in orbit, with more room, a bigger crew, and far more computer and electrical power than the aging Russian Mir, due for a fiery death in the atmosphere late next month. It's also expected to be open all day, every day, for more than a decade. Once fully outfitted, 13 of the new module's 24 closet-sized racks holding equipment will be devoted to research, and the rest to operational systems. In time, the space station's scientific capacity will be augmented by modules with European and

CREDIT: S. PADIN *ET AL.*