of the roughly 60-member BICEP team.

BICEP researchers have taken heat from some of their peers for overstating their result. But François Boulanger, an astrophysicist at the University of Paris-Sud in Orsay, France, and a member of the Planck team, notes that the joint analysis showed that the dust emission was stronger and its polarization varied more from place to place than previously expected. "One has to be fair to the BICEP team," he says. The delicate joint analysis took 6 months, Boulanger says, "and we went through some stages where we thought there probably was a [gravitational wave] signal."

Researchers are optimistic about their chances of spotting the real thing soon. Physicists quantify the B-mode signal using a parameter r, which is the ratio of the strength of the peculiar oscillation of gravitational waves to the strength of more-conventional waves such as sound waves in the early universe. The joint analysis shows that r must be less than 0.12. But if r is close to that limit, then a half-dozen experiments now under way or in the works could detect primordial B modes in the next few years.

For example, John Carlstrom, a cosmologist at the University of Chicago in Illinois, and colleagues will soon deploy SPT3g, an upgrade of the 10-meter South Pole Telescope, which is also in Antarctica. Taking data at three frequencies, SPT3g should be able to detect primordial B modes if r is 0.05 or greater, Carlstrom says. Similarly, Staggs and colleagues are working on Advanced ACTpol, an upgrade to the Atacama Cosmology Telescope in Chile, that will take polarization data at five frequencies. And Kovac and colleagues have already taken data at a second frequency with BICEP2's successor, the Keck Array, and are installing BICEP3.

In case the gravitational wave signal slips past those telescopes and others, cosmologists are developing a plan for a network of telescopes that would have 10 times more sensitivity and could detect B modes if r were as low as 0.005. The $100 million effort would link telescopes at the South Pole, in Chile, and possibly in Greenland or Tibet. In a road map for their field released last May, U.S. particle physicists strongly endorsed the idea, and researchers are hopeful that the Department of Energy will fund it and have it running in the next decade.

After the BICEP2 episode, researchers are quick to say that the discovery of primordial B modes probably won't come in one decisive measurement. "I think it will happen as these things have always happened," Carlstrom says. "Hints will show up earlier." Still, Kovac says, "the bottom line is that we're all feeling very optimistic." ■

PHOTO: ROB PRINGLE

ECOLOGY

Africa's soil engineers: Termites

Kenyan plots show that termite mounds promote ecological health and may slow desertification

By **Elizabeth Pennisi**, *in Mpala Research Centre, Kenya*

Truman Young still remembers his amazement more than a decade ago when he and his colleagues had their first aerial look at the African dryland landscape that they had been studying. From the ground, the acacia trees and bunch grasses seemed randomly distributed—and so did the termite mounds scattered across this combination ranch-field station in central Kenya. But satellite photos taken in 2003 showed these mounds were actually like polka dots, spaced far enough to avoid territorial battles. More startling, a satellite image sensitive to chlorophyll revealed that termite mounds are hotspots for plant growth.

The photo "changed the way we thought" about what shapes this landscape, recalls Young, an ecologist at the University of California, Davis. For decades, thanks primarily to National Science Foundation funding, he and his colleagues have run the Kenya Long-term Exclosure Experiment (KLEE) here, which uses fenced-in 4-hectare plots to assess how elephants, cattle, and other grazing animals affect the savanna. But after studying that image, Young suddenly realized termites had to be added to this list.

"We all tend to think about large mammals as being the big dominant driver of what's happening in the savanna, but the more we look at the termite mounds the more they seem to be driving what's going on," says Robert Pringle, a Princeton University ecologist who works at Mpala. A study on page 651 presents the latest example. By modeling the interactions of termites, rainfall, soil, and plants, Pringle and his colleagues conclude that the termite mounds are an insurance policy against climate change, protecting the vegetation on them from water scarcity.

Jef Huisman, a theoretical biologist at the University of Amsterdam, says the results show that "termite mounds play a key role in arid landscapes." The work also calls into question whether land managers can forecast looming desertification based on aerial views of the landscape. "We should not blindly adopt the early warning indicators predicted by simple models," Huisman says.

Africa's indigenous people have long recognized that the soil in termite mounds is richer than normal and good for crops. Harvester termites, such as the fungus farmers that live at Mpala, spend their days retrieving vegetation to fertilize "gardens" of microbes and fungus, which concentrate nitrogen, phosphorus, and organic matter. At the same time, the termites alter the soil profile as they build their tunnels. In some places, termites add clay to stiffen soil too sandy for tunnels. At Mpala, they dilute the clay-laden soil with sand, making it easier to excavate. "In both cases, it's making a soil that's better than background," Young says. So plants grow more readily. The excavations also help the mounds better hold on to water. "At the right

Zebras, elephants, and other grazing animals prefer a termite mound's nutrient-rich grasses.

time of year, the mounds are all green and the rest of vegetation is all brown."

Even the savanna's iconic acacia trees benefit. They don't grow right on termite mounds, but Todd Palmer, an ecologist at the University of Florida in Gainesville, helped determine that acacia growing next to mounds have higher nitrogen concentrations and were more likely to produce fruit than trees farther away.

All told, the termite mounds create "nutrient islands" that sustain many other animals besides termites. More than a decade ago, as a graduate student, Palmer had noticed that ant colonies were biggest along the edges of termite mounds. Because of the lusher plant growth, the mounds supported more of the insects that ants prey on. "These mounds are really the supermarkets of the savanna," Palmer says, also attracting zebra, buffalo, eland, and other plant-eating mammals.

By trapping all the insects flying and crawling on and away from mounds, tracking the offspring of insect-eating spiders, and counting geckos, Pringle, Palmer, and their colleagues found that all are bigger, more numerous, or more prolific near mounds. Furthermore, computer simulation studies showed that the regular spacing of the mounds enhances these beneficial effects by minimizing the average distance that animals have to travel to reach the nearest mound.

The latest termite study grew out of a collaboration between Pringle and Princeton theoretical ecologist Corina Tarnita. It examines a widely accepted theory that vegetation in dry places will arrange itself in regularly spaced clumps, instead of forming a uniform lawn as happens in wetter places. Because each plant's roots alter the soil to help concentrate water and slow its loss, plants in dry places prefer to grow close to other plants. Yet these emerging clumps suck water from more distant surrounding soil, making the space in between inhospitable to plants. As the environment dries, the space between clumps should expand. And theory predicts that "if you turn down the water enough, you get a catastrophic shift to desert," Pringle says. As a result, the presence of vegetation clumps may signal an ecosystem in danger.

Given the aridity of the climate at Mpala, Tarnita expected to see the telltale clumping in the plants. But no matter how hard she and Pringle looked, the only pattern they saw in the vegetation was the one established by the termite mounds. Then one day they visited an area that another researcher had burned to study how different grazing species affect plant regrowth. Instead of being overgrown with tall grasses, the burn area had just stubbly ground cover. When they stood on the roof of their Land Rover, Tarnita and Pringle thought they saw hints of a pattern in the vegetation. Then two graduate students rigged a fishing rod that could hoist a camera 10 meters up. The photographs showed that the new growth formed a uniform lawn on the termite mounds. But in between, Princeton postdoc Efrat Sheffer could make out a pattern of clumps just 20 centimeters wide, created by self-organization among the plants. "There was the vegetation pattern that prior models had predicted, but it was on the scale of centimeters," Tarnita says.

Plant-covered termite mounds dot Mozambique landscape.

To gauge how termite mounds shape the pattern, the group turned to the mathematical models that had previously suggested vegetation clumps are bellwethers for desertification. The models usually treat all soil as uniform, but Tarnita modified them to include patchy nutrient islands.

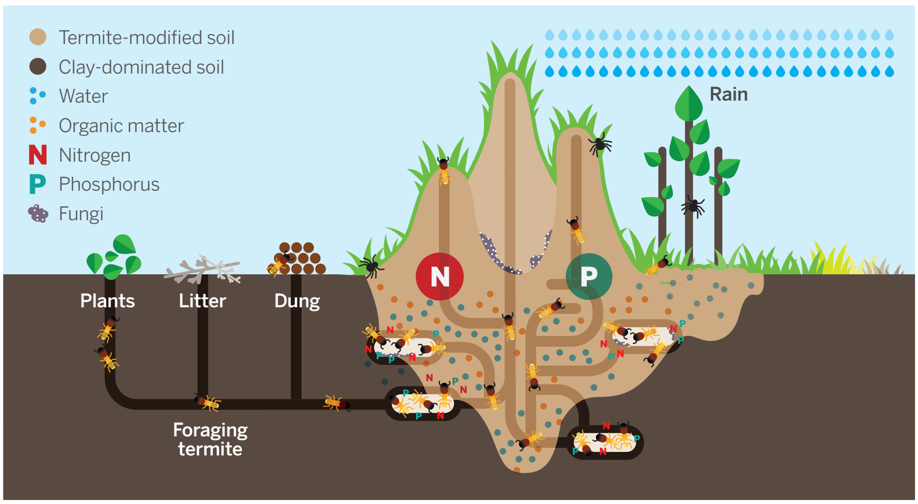
Tarnita and Juan Bonachela, now at the University of Strathclyde in the United Kingdom, provided the model with different rainfall scenarios, and it predicted what would happen to the plants on and off the mounds over time. In dry conditions, the vegetation on the termite homes persisted, despite a 30% decline in the vegetation off the mounds, indicating termites' remodeling of the soil can slow the loss of vegetation, the Princeton team now reports. And when the group restored rainfall in the model, the remaining vegetation on the mounds helped revegetate the whole area.

But there is a downside: The modeling work suggests that there's no easy way to predict when an arid landscape is on the verge of collapsing. Vegetation clumping may be due to termite mounds rather than an unhealthy environment. "The use of vegetation patterns to predict desertification in general is in urgent need for validation," says Max Rietkerk, an ecologist at Utrecht University in the Netherlands. And the work suggests that the savanna may lose resilience when it is transformed into farms. "When agriculture takes over, we lose the termites and their mounds," Palmer explains. Cultivated lands are "likely to be much more vulnerable to climatic variability and much more likely to tip over into more permanently degraded landscapes."

Meanwhile, the termite studies at Mpala continue. Experiments by Pringle, Tarnita, and Dan Doak from the University of Colorado, Boulder, are testing the mounds' additional roles in slowing degradation of the landscape. Grace Charles, one of Young's graduate students, has been analyzing how large herbivores affect the density of the mounds or vice versa. For Young, the termites "started as noise in the background" of the KLEE research. But now, he says, "they are front and center." ■

Nutrient islands

Foraging termites concentrate plant material in mounds, where fungi process it into soil-enriching nitrogen, phosphorus, and organic material, fostering more plant and animal growth. Mounds also retain water better than surrounding soil.



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