

Emilio Bruna, an ecologist at the University of Florida in Gainesville who studies habitat fragmentation in the Amazon and the Cerrado. Two of his students moved their projects to Costa Rica and Ecuador.

Amendments to MP 2186 gradually eased restrictions on basic research. But prospecting for natural compounds remained a daunting challenge. Before starting research, scientists and companies had to get permission from CGEN and sign a benefit-sharing contract with the indigenous group identified with a particular resource. “How can you sign a contract for a product when you don’t know if it’s going to work, or even if it’s going to exist?” asks Paulo Sérgio Beirão, a biochemist at the Federal University of Minas Gerais in Belo Horizonte.

Under the new law, Brazilian scientists need not ask CGEN for permission to do research. All they must do is register their project in a database and document permission from the appropriate indigenous group. Contracts and other legal matters will come into play only if research leads to a product. “A clear distinction is made now between scientific research and technological development for commercial purposes,” says Francine Leal, an environmental lawyer in Curitiba who has consulted on the law. Foreign scientists are prohibited from prospecting for genetic resources in Brazil, unless they are part of a company or institution that strikes a partnership with a Brazilian counterpart.

The law is getting a cool reception from indigenous and other local groups, who believe the rules of access to traditional knowledge and benefit sharing are skewed in favor of companies. “The law moves in the right direction for science and technology,” says Carlos Joly, a plant ecologist at the University of Campinas and a key figure in the regulation of biodiversity research in Brazil, “but there are still major problems with it.” For instance, he says, the law is blurry about the rights of indigenous and local communities to withhold access to traditional knowledge, if they felt an agreement would not benefit them.

Jared, at least, would have fared better under the new law, which abolishes the case-by-case permits for shipments abroad: It only requires noting them in a registry. “The spirit of the law,” Fontes says, “is to trust researchers.” But for Jared, the moment may have passed. He can retrieve his velvet worms from the University of São Paulo’s zoology museum, where they were deposited for safekeeping, but the German colleague he hoped to collaborate with has long since retired. ■

*Herton Escobar writes for O Estado de São Paulo.*

## AGRICULTURAL RESEARCH

# Reading the tea leaves for effects of climate change

### Cloudy forecast for crops cherished for their complex flavors

By **Christina Larson**,  
in *Xishuangbanna, China*

“Taste it,” Selena Ahmed says, offering a delicate green bud plucked from a tea plant on a terraced hillside here. It’s like a tiny cup of espresso: bitter at first, then a caffeine buzz. When Ahmed returns to Montana State University, Bozeman, the ethnobotanist will analyze chemical constituents of the leaves along with other data, looking for clues to how climate change will affect the taste of the tea for which southwestern China’s Yunnan province is famed.

“We drink tea for the quality, not because it’s providing energy [from] calories,” says Sean Cash, an applied economist at Tufts University in Massachusetts, who works

What they find could have implications for scores of other crops, from coffee to chocolate to cherries, whose taste and value also depend on local climates (see p. 954). “Our agricultural system has adapted to a set of conditions that are now in flux,” says Samuel Myers, an epidemiologist at Harvard Medical School in Boston who studies how rising carbon dioxide concentrations in the atmosphere alter crop nutrients. “Understanding the implications on both quantity and quality is very important.”

“Rainfall is central for tea,” says Colin Orians, a chemical ecologist at Tufts, who is collaborating with Ahmed and Cash. In Xishuangbanna, “the monsoon rains come, and within 5 days, the quality of tea really drops. You can see big shifts in the chemistry.” During the summer monsoon, which brings 80% of the annual rainfall, tea leaves grow



A Hua farmer in Yunnan province picks tea leaves that will later be fermented into the prized pu'er variety.

with Ahmed. The complex mix of phytochemicals responsible for its taste may be far more sensitive to climate than are the yields of commodity crops. And an ideal place to study the relationship is tropical Yunnan, known for an oxidized and fermented black tea called pu'er, one of China’s most prized and already being touched by climate change. Earlier this year Cash, Ahmed, and others embarked on a 4-year project backed by the U.S. National Science Foundation that examines the linkages among climate, tea quality, and farmer livelihoods.

roughly twice as quickly as in the dry season. That’s not as happy a prospect for farmers as it sounds, says Wenyan Han of the Tea Research Institute in Hangzhou. “Quality and yield often exist in inverse balance,” he says. “If one goes up, the other goes down.” Here in the Bulang Mountains, pu'er harvested in the spring, before the monsoon, tastes richer and fetches a premium: \$680 per kilogram, compared with \$405 for summer pu'er, harvested during the rainy season.

Orians and colleagues have traced the chemical shifts responsible. During the

## The endangered palates list

Climate change threatens crops beloved for rich flavors rather than caloric content. Here are a few of the most vulnerable:

**COFFEE** Growers face a grim outlook for the Arabica bean, source of 70% of the global coffee supply. According to a 14 April report in *PLOS ONE*, a temperature rise of 2°C to 2.5°C by midcentury will wreak havoc on Arabica harvests globally. Brazil will “suffer great losses,” losing up to 25% of its territory suitable for the highland-loving plants, says Peter Läderach of the International Center for Tropical Agriculture in Cali, Colombia.

**COCOA** Warmer weather and more frequent droughts in West Africa, especially Ghana and Ivory Coast, will raise evapotranspiration rates in cocoa plants, which means less water for pods and lower yields of chocolate’s main ingredient.

**MAPLE SYRUP** Late winter, when the mercury begins to edge above freezing, is the time to tap sugar maples. Sap flows “when temperatures fluctuate around freezing, between day and night,” says Joshua Rapp, a biologist at the University of California, Davis. Warming in eastern North America is shortening the sap season and curtailing maple syrup production.

**CHERRIES** Wild temperature swings are bad news for fruits. Cherry trees are especially sensitive. In 2012, a frigid winter followed by a warm spring destroyed 90% of Michigan’s tart cherry crop, decimating supplies for pies, jams, and confections.

**TOBACCO** Call it global warming’s health dividend. The leaves and roots of tobacco grown in elevated CO<sub>2</sub> environments have less nicotine, the secondary metabolite that makes cigarettes addictive, according to the Institute of Plant Genetics and Crop Plant Research in Germany. ■

monsoon, when growth speeds up, leaf concentrations of two key groups of secondary metabolites—catechins and methylxanthines—fall to half their dry-season levels, they reported last October in *PLOS ONE*. Secondary metabolites protect plants from threats such as excess UV exposure or pests, and some of these compounds have potent effects in humans as well. Catechins, also found in blackberries and grapes, are antioxidants linked to improved cardiovascular health, reduced prostate cancer risk, and lower blood cholesterol. Caffeine and other methylxanthines are central nervous stimulants.

Dilution is unlikely to be the only explanation for the fall in secondary metabolites during the monsoon, Ahmed says. Higher temperatures, cloudier days, and different insect pests could all have an effect. “If a plant doesn’t have a cue to produce high concentrations or specific secondary metabolites, it won’t,” she says. Her team has identified 59 seasonally unique compounds in tea, the majority of them in the higher quality spring tea, they reported last November in the *Journal of Chromatography A*.

The mix is likely to change. Average temperatures in Kunming, Yunnan’s capital, have climbed 1.5°C over the past 50 years. And the monsoon is arriving later: In 2011, it began some 22 days later than in 1980, Cash and colleagues report in a paper under review at *Climatic Change*.

Because land warms faster than ocean, the land-sea temperature gradient that drives Asian monsoon systems will increase. “In very broad brushstrokes for the 21st century,” summer precipitation “may be more intense,” says Caroline Ummenhofer, a geographer at the Woods Hole Oceanographic Institution in Massachusetts, although she notes that the projections are uncertain.

“Climate change is not necessarily all doom and gloom for farmers,” Ahmed notes. If the dry season grows drier and the wet season grows wetter, as most climate models predict, the dry-season harvest could become even more valuable as the stressed plants boost their production of secondary metabolites and improve pu’er tea’s flavor.

But prolonged dryness has diminishing returns. “If the weather is too dry, that can reduce the number of buds” or kill plants, Ahmed says. That’s already a concern in India’s Assam region, famed for its black tea. Summer days in Assam more frequently top 35°C—the “upper limit for growing tea,” says Ellie Biggs, a geographer at the University of Southampton in the United Kingdom.

Tea lovers can only hope that the prognosis for tea in a changing climate doesn’t pan out like the finest pu’er: bitter and black. ■



### REGENERATIVE MEDICINE

## Report finds misconduct by surgeon

Papers omitted data on patient complications, investigator finds

By Gretchen Vogel

**A**n investigation has concluded that surgeon Paolo Macchiarini, famous for transplanting tissue-engineered tracheae into more than a dozen people, committed scientific misconduct in publications describing the results of the operations. The Karolinska Institute in Stockholm, where Macchiarini is a visiting professor, commissioned the external inquiry after allegations arose in August 2014.

The investigator, Bengt Gerdin, professor emeritus of surgery at Uppsala University, examined six papers about the patients and one on animal tests of the procedure and found “a systemic misrepresentation of the truth that leads the reader to have a false impression of the success of the technique,”