

writes Daganzo's graduate student Monica Menendez in an ITS research report (managing to make their mathematical assumptions sound like the product of road rage).

The model has been validated by data from the Berkeley Highway Lab, a collection of vehicle detectors and cameras that monitor traffic along I-80 between Powell and Gilman Streets in Emeryville and Berkeley. Run in association with the California Department of Transportation, the lab tracks vehicles passing through its stretch of highway with an accuracy of 1/60th of a second, giving a uniquely detailed picture of traffic flow in this busy corridor.

Armed with their lane-changing model, Daganzo and colleagues then modeled the impact of various strategies for controlling congestion. A strategy familiar in California is reserving lanes for high-occupancy vehicles (HOV lanes), which can make people decide to carpool and thus decrease the number of vehicles on the road. Daganzo's models describe how HOV lanes preferentially reduce congestion for vehicles with more passengers, hence decreasing the total person-hours of delay. Additionally, by analyzing flow at bottlenecks, Daganzo found that under certain conditions, reserving a lane for HOV use will not reduce the non-HOV traffic flow.

While it may seem that HOV lanes can only be helpful if they are being used, the study found a paradoxical result. When a lane is taken away from general use and restricted to HOVs, its presence can increase the total flow at a bottleneck even if no HOVs use that lane, by reducing the number of lane changes. Usually, when traffic reaches a bottleneck, drivers try to change lanes to find one that goes faster; but every time a car changes lanes from a slower lane to a faster one, it forms a moving bottleneck that compels the cars behind it to slow down until the lane-changer accelerates to the new speed. Cars farther behind see this lane slowing down and may change lanes too, setting off a chain of disruptive lane changes. Ultimately, the lane changes create voids in the traffic that reduce the density and thus the flow. Removing lane changes into and out of the HOV lane reduces the opportunities for disruptive lane changes and increases the flow. Working with ITS director Professor Michael Cassidy, Daganzo verified this phenomenon in the field, and is discussing with Caltrans the implementation of lane-change bans at critical bottlenecks; these could be turned on and off dynamically based on traffic flow.

Another strategy for controlling congestion is ramp metering, in which a traffic light at an on-ramp controls flow onto a highway during busy times to prevent the flow reaching the jam density (you can see this in action at most I-880 on-ramps from the McAfee Coliseum to San Jose). Daganzo has proposed monitoring traffic and controlling access to roads across the whole city to improve urban mobility and reduce gridlock. Simulations of traffic in downtown San Francisco have generated a reproducible "macroscopic fundamental diagram" describing flux and density over this large area rather than in just a single lane. The density could be controlled to maintain maximal flow, like on a highway. Moreover, he is now studying how to predict this diagram from the street network of a city to understand how to increase the flow for a given density. The results can be applied to planning the infrastructure in a large and

congested developing city such as Nairobi, Kenya.

Daganzo's work in understanding traffic flow and mitigating gridlock may be used in designing future roads. But for now, the next time you're stuck in traffic and trying to change lanes to go a little faster, remember: you may just be making the traffic more congested and irregular for everyone.

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Want to know more?

Check out Carlos Daganzo's webpage:

ce.berkeley.edu/~daganzo

Berkeley Highway Lab website:

bhl.its.berkeley.edu:9006/bhl/traffic/current.html



PHOTO COURTESY OF ERIC HARRIS

Mighty moss

Tracking the cultural conservation of traditional medicine

At first glance, Eric Harris's bookshelf looks like that of any other integrative biology graduate student. There are all the usual textbooks: Campbell's *Biology*, Zar's *Biostatistical Analysis*, Futuyma's *Evolutionary Biology*. But then come all the books in Chinese.

Harris, who received his PhD in Integrative Biology from UC Berkeley in 2006, works in the area of ethnobotany, the study of the interaction between people and

plants. More specifically, Harris studies the traditional Chinese medicinal use of moss. His goal is to learn how both Chinese culture and the biological activity of the moss influences its use by humans. As a PhD student, Harris made several trips to China to study medicinal mosses and to speak with traditional herbalists. On these trips, he found that the continuation of China's long tradition of herbal medicine requires sustainable populations of herbs and the ongoing communication of herbal knowledge, both of which are threatened by China's rapid growth and modernization.

Harris' research focuses on the moss *Rhodobryum giganteum*, which is used to treat arrhythmia (irregular heartbeat) and heart palpitations. He chose this particular moss because it is the only species of moss that is frequently used for medicinal purposes in modern China. As Harris traveled throughout

(right) A Chinese herbalist at a local village market.

(below) *Rhodobryum giganteum* is a medicinal herb that is steeped as a tea and mixed with the juice of the jujube fruit, or ground into a powder and packed into the veins of a pig's heart, which is then boiled and eaten.

(facing page) Produce at a local Chinese market includes jujube, also known as Chinese date, and the medicinal moss, *Rhodobryum giganteum*. A prescription of moss is measured into the newspaper.

the Yunnan province of southwest China, he found that the moss was always used in the same way—it is either mixed with the jujube fruit and steeped as a tea, or ground into a powder and packed into the veins of a pig's heart, which is then boiled and eaten—and is always used to treat heart problems. Furthermore, research in China has shown that the moss increases blood flow in the aorta of dogs, rabbits, and rats. However, the identities of the medicinally active chemicals in the moss are still unknown, and it is not clear which biochemical pathways are involved in the moss's physiological effects.

Because of its popularity, Harris was not surprised to see this moss sold in markets. However, he was shocked to see such enormous quantities of moss on display—in fact, *Rhodobryum giganteum* has become a popular souvenir. “Yunnan is famous for being the kingdom of plants,” he says, “and it is a popular destination for the increasing number of tourists from Beijing.” Many people want to return home with the specialty herbs of the region, so they pick up a pre-packaged bag of moss at the market.

In light of this brisk trade, Harris began to wonder about the sustainability of harvesting medicinal herbs. “There are these massive sacks of moss,” he says. “So much is being collected, which makes you wonder how much is out there. And how long does it take to grow back? In general, moss takes a long time.” Harris went on collecting trips with herbalists, who shared his concern. “They said ‘We can't collect it in the same spots anymore—it's gone.’ Many herbalists had a sense of wanting to keep the moss there, if for nothing else than being able to collect it next year.”

For herbalists, the sustainability of herb populations is necessary to sustain their own livelihoods. But overharvesting isn't the only threat faced by herb populations: China is undergoing rapid land use change and ur-



banization, both of which threaten to destroy herb habitats. In addition, overharvesting may become a more pressing problem in the future, as Western medicine is taking an increasing interest in herbs used in traditional medicine. “Pharmaceutical companies are conducting high-throughput trials, targeting the medicinal herbs used in many cultures, particularly Chinese herbal medicine and Ayurveda, in order to determine their efficacy as Western pharmaceuticals,” Harris explains. Successful trials could increase harvesting pressure on wild populations.

In the near future, Harris plans to



research the extent to which overharvesting is impacting moss populations. The first step will be to determine where the herbs sold in markets and stores came from. Each regional population of moss has a particular genetic signature, or “DNA fingerprint”, which makes it distinct from all other populations. Harris will sample and sequence the DNA of moss found in stores, markets, and the wild, and compare their DNA fingerprints. This analysis will allow him to map the patterns

of herbal trade and identify moss populations that are in danger of being overharvested.

The loss of knowledge is another threat to the practice of herbal medicine. China has a long history of medicinal herb use, as Harris's bookshelf attests: One of his books, a Chinese herbal compendium, was written in the late 1500s. Next to it is a set of “little herb books” published in the 1970s, when Mao Tse-tung commissioned the military to write herb guides for each region of the country in an attempt to unify the practice of herbal medicine. Much of the knowledge of herbal medicine is recorded in these books, but information about many rare herbs is still passed down orally. This knowledge is in danger of being lost amidst China's rapid economic development. Young would-be herbalists are foregoing traditional careers in favor of jobs in China's expanding cities. With the loss of knowledgeable herbalists, says Harris, “some of the specificity of herb use is being lost. Many people now just use the books.”

Perhaps today's pharmaceutical research will put new books about herbal medicine on Harris's shelf. But to bring the tradition of Chinese medicine into the 21st century, there is a growing need to conserve both the knowledge of traditional herbal medicine, and the herbs themselves.

JENNIFER SKENE is a graduate student in integrative biology.

Want to know more?

Check out Harris's website: ericsjharris.com

The Tree of Life site: tolweb.org/Bryophyta