

WATER RESOURCES

Data Drought, Data Flood

Jared Farmer

Located on either side of the Grand Canyon, Hoover Dam and Glen Canyon Dam can each hold back about two years' flow of the Colorado River. The resulting reservoirs, Lake Mead and Lake Powell, are listed in encyclopedias as the two largest by volume in the United States. Yet both stand half empty today. According to James Lawrence Powell (the executive director of the National Physical Science Consortium), the present is the future. In the coming era of global warming, Lake Powell may never reach "full pool" again.

The root problem, Powell argues in *Dead Pool*, is that water managers in the Southwest have belatedly and incompletely come to grips with two sets of scientific data—one historical and descriptive, the other theoretical and predictive.

The first set concerns the average historic flow of the Colorado. Insufficient data led to bad policy in 1922, when the Senate ratified the Colorado River Compact. By the terms of this interstate agreement, the Upper Basin (Utah, Wyoming, Colorado, and New Mexico) could use up to 7.5 million acre-feet (MAF) of the river per year—averaged over ten years—provided that the Lower Basin (California, Nevada, and Arizona) received the same amount first. On the basis of streamflow measurements, government scientists had calculated that the Colorado carried 18.5 MAF per year on average. By allocating "only" 15 MAF, the Compact seemingly left a comfortable cushion for yet-to-be-determined Mexican water rights, Native American water rights, and the vagaries of climate.

Unfortunately, the data—a 26-year sample from a 5-million-year-old river—came from a wet period. The average flow of the Colorado for the 20th century turned out to be just about 15 MAF. And recent dendrochronological research suggests that the average over the past millennium was lower still. In other words, politicians overallocated the river. For decades, the Lower Basin lived on bor-



Drought-lowered lake. Bathtub rings encircling the waters impounded behind Glen Canyon Dam.

rowed water—and borrowed time—as the Upper Basin did not fully use its share. But since 1999 the combination of persistently dry weather and explosive metropolitan growth has exposed cracks in the system. A mega-drought—the kind of dry spell recorded repeatedly in tree rings—could induce systemic failure. In a belated response to streamflow recalculations, the seven Colorado River states in December 2007 signed a cooperative agreement that allows joint management of Lakes Mead and Powell in times of drought.

According to the author—a scientific gadfly—the new pact is already out of date. Here's where the second data set comes in. Recent climate modeling—some of it published in *Science* (1–3)—predicts that global warming will produce outstandingly large effects on the U.S. Southwest. Increased temperatures will lead to smaller snowpacks in the Rockies, and these will melt sooner and more completely. As a result, snowmelt will rush downstream before the peak-use months, more of it will evaporate from low-elevation reservoirs, and more of it will be absorbed by dried-out soil. Warming will also cause mountain ice to sublimate at a

higher rate. For all of these reasons, less liquid will be available in the lower Colorado for human consumption.

Using simple open-source spreadsheet software that simulates the flow of the Colorado River (4), Powell tries to quantify the probable impact of global warming. His projections are provocative. Contradicting the U.S. Bureau of Reclamation's forecasts, Powell's trend lines point to systemic failure by 2050. The urban Southwest could violently contract, and Phoenix could depopulate in "a *Grapes of Wrath*-like exodus in reverse."

How can policy-makers avert this doomsday scenario? Powell touches on various proposals, starting with cloud seeding, importation of water from the Columbia River, and ocean water desalination. The first, at a scale large enough to solve the problem, is scientific fantasy; and the second seems like economic and political wishfulness. In contrast, desalination holds promise—although cost-effective, carbon-neutral technology remains elusive without nuclear power. Other partial solutions include subterranean water banking, water conservation and recycling, the retirement of irrigated farms, and the swapping of water rights among different political entities in the river basin.

The vulnerability of the Southwest's water regime has an indicator site: Lake Powell behind Glen Canyon Dam. This impoundment took a "quick" 17 years to fill—and that was during a wet period, 1963–1980. In a warmer, drier future, the Bureau of Reclamation could be forced to operate Glen Canyon Dam at "dead pool": minimal storage with no power production and outflow matching inflow. Maintained at its lowest level, Lake Powell might fill with sediment in decades rather than centuries. Environmentalists have long wished to drain "Lake Foul" and restore the legendary beauty of Glen Canyon; their passionate wish might yet be granted if cold-blooded decision-making prevails. The author argues that there will only be enough water for one big reservoir on the Colorado and that Lake Powell should be sacrificed for a maximal Lake Mead, which services Las Vegas directly and holds greater hydroelectric capacity.

Dead Pool won't win awards for original research or splendid writing. It does, however, offer a solid primer on the history of use of Colorado River water and the science of climate change. The legal, political, economic, and social ramifications of Powell's predictions would require a book of their own. But the author's main purpose is science

Dead Pool

Lake Powell, Global Warming, and the Future of Water in the West

by James Lawrence Powell

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advocacy. Powell wants regional policy-makers to respond to the flood of data on global warming. Otherwise, he says, westerners will find themselves in a megadrought of their own making.

References

1. E. R. Cook, C. A. Woodhouse, C. M. Eakin, D. M. Meko, D. W. Stahle, *Science* **306**, 1015–1018 (2004).
2. R. Seager *et al.*, *Science* **316**, 1181–1184 (2007).
3. T. P. Barnett *et al.*, *Science* **319**, 1080–1083 (2008).
4. www.onthecolorado.org/cross.cfm.

10.1126/science.1169644

LINGUISTICS

Pondering Grammar and God

Andreea S. Calude

Contemplate your life as it is now, the things you hold most dear to you, family, and the beliefs and values you have adopted and hold true. What would your life become if you were to lose them all? Who might you be? These are questions that Dan Everett faced in the course of his fieldwork among the Pirahã people of the Amazonian jungle. *Don't Sleep, There Are Snakes* offers Everett's personal account of the language and life of the tribe and, at the same time, a close-up of his life and experiences in making sense of this new world.

As a trained linguist and devoted Christian, Everett (now in the Department of Languages, Literatures, and Cultures at Illinois State University) set out with his wife and three children to bring the word of God to the Pirahãs. Aiming to succeed where other missionaries had failed, he tried to master the famously difficult Pirahã language (for which the tribe is notorious in linguistics circles) and to break their recalcitrant rigidity toward alien faiths. In a twist of fate, Everett lost all: God, wife, and even linguistic ideology. The Pirahãs left him stripped of these but, in return, provided their own take on life. They taught him about the “immedi-

acy of experience”—the principle he locates at the heart of the Pirahã language and culture. According to Everett, living and speaking for the moment allows the tribe's members to enjoy each day as it comes, to avoid stress and the burnouts that result from worrying about the future, and to disregard the regret and guilt of the past.

The book has two parts. The first describes everyday life within the tribe. Although lacking any temporal organization, this narrative talks in an honest and raw voice about birth, death, eating, hunting, rituals, spirits, sex, family and kinship, growing up, and community among the Pirahãs. The people and stories are intertwined with Everett's own life: as a husband fighting to save his wife and daughter from a near-fatal bout of malaria, as a linguist and fieldworker coping with first-language and first-culture biases, as a Christian coming to terms with dissipating faith, and as a foreigner in a community plotting to kill him. Despite a few confusing aspects of the story (such as how the individual Pirahãs mentioned in the book interact with one another), the prose lures the



Immersed among the Pirahãs. Everett with Kaabohoá.

reader with vivid and unexpected incidents that leave one pondering when the movie might be coming out.

The second part focuses on the linguistic aspects of Everett's Amazonian experiences (primarily on the Pirahã language and, more generally, on the author's own ideas). The author trained within the generativist school, founded by Noam Chomsky, that has largely dominated the linguistics arena over the past 50 years. Generativists endorse the idea of an innate universal grammar and propose that language acquisition is, at least to some con-

siderable extent, innate. Like many of the beliefs the author held when he arrived in the Amazon, generative grammar was soon questioned and discarded because it had “little enlightening to say about the Pirahã language.” The “straight head,” as the Pirahãs term their

language, appears to lack terms for color, number, (distant) past events, and quantifiers. Everett goes so far as to claim that the language lacks recursion, the ability to put one phrase or sentence inside another (in a “matrioshka-doll effect,” as eloquently put by Everett). The absence of recursion is extremely difficult to swallow—not just by Chomskyans, but by any linguist. These claims remain

highly controversial and many linguists dismiss them; however, a field often benefits from the reexamination of some of its more cemented assumptions. Nonetheless, although such health checks are good for the field, they are often extremely tough on those who instigate them.

It is not clear for whom the second part of the book was written. The discussions there are too simple and introductory for the practicing linguist and probably too long and clamoring for the lay reader—although Everett offers good explanations of some basic ideas from linguistics (such as the concepts of tones and tonal languages and the distinction between phonemes and allophones). To his merit, however, the author includes several transcripts of conversations with the Pirahãs. His willingness to present these demonstrates his confidence in his interpretations, and the transcripts add credibility to his argument.

The book is fascinating. In part, that is because Everett provides a personal glimpse of a tribal people living in a remote jungle. More important, we see the world of the Pirahãs through the lens of a unique source: someone whose own world is turned upside down and who possesses an inquisitive and adventurous mind that is, at times, very much in conflict with itself. In addition, *Don't Sleep, There Are Snakes* may serve to bring the furor of linguistics and language research to readers who would otherwise never catch sight of it.

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Don't Sleep, There Are Snakes

Life and Language in the Amazonian Jungle

by Daniel L. Everett

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Profile, London, 2008. £15.

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