people each year in the developing world.

But to meet that target, Association Ifriqya will have to surmount formidable hurdles. Creating an international center of excellence is easier said than done, warns Robert Walgate, a spokesperson for the tropical disease research program at the World Health Organization (WHO). Walgate cites the Ndola Center for Tropical Disease Research (CTDR) in Ndola, Zambia, which received $10 million from WHO during the 1980s. In the absence of the necessary infrastructure—for example, a local network of research institutes to ensure that company technicians would come to the region to service laboratory equipment—CTDR "never fulfilled its promise of being an international center," Walgate says. In the end, WHO decided to discontinue funding CTDR, which now conducts epidemiological research and surveillance for Zambia. But Cohen expects fewer problems in Tunisia, one of the most scientifically advanced of the African countries. "Tunisia has lots of universities, a Pasteur Institute, and research hospitals. It's not a typical African country, but it's the best place to start," he says.

But there is still the question of money. In addition to the $4 million needed to complete the IGRDC buildings, Cohen estimates it will cost $5 million a year to run the institute—and at the moment, it's not clear where those funds will come from.

IGRDC plans to seek support from the agencies that traditionally make funds available internationally, such as the European Union's research directorate. Until IGRDC has proved itself, however, those sources of funding are unlikely to be generous. To meet the expected shortfall, Cohen plans to continue tapping his private donors, while cajoling institutes engaged in genome research in industrialized countries to donate 2% to 5% of their budgets. Cohen admits it's not easy to get institutes to cough up. Indeed, even the CEPH board refused to part with 2% of its budget—about $200,000—until the French minister of higher education and research François Fillon made clear his support for research in developing countries, says Cohen. Nonetheless, some institutes are taking Cohen up on his proposal.

"I haven't made a dollar commitment yet, [but] we've discussed it and [The Institute of Genomic Research (TIGR)] is going to try and do something," says Craig Venter, director of TIGR, the private genome research institute in Gaithersburg, Maryland. "I've also offered to help [Cohen] raise funds." Cohen, meanwhile, is planning to follow up on his earlier successes. At the next Association Ifriqya fund-raising extravaganza in February in Paris, he plans to conduct part of the orchestral version of Giuseppe Verdi's *La Forza del Destino*.

**–Rachel Nowak**

POLAR ECOSYSTEMS

# Rustic Site Draws a Crowd To Monitor Global Warming

**TOOLIK LAKE, ALASKA**—On a calm day, the only sound you hear on the shore of this steely blue lake 170 miles above the Arctic Circle is your lungs filling and emptying. The bustle of civilization lies hundreds of miles to the south of this treeless, frozen land, below the rough-hewn Brooks Range that separates Alaska's North Slope from the rest of the world. But the mountains are no longer an impediment to a growing number of scientists who believe that some of the hottest action in long-term climate change is going to occur at the poles. Backed by the National Science Foundation (NSF), they are streaming to Toolik Lake to characterize a swath of the North Slope environment before human activity refashions it and obliterates the baseline data. "We want to use the Arctic as a canary in the mine," says Bruce Peterson, a stream ecologist at the Woods Hole Marine Biological Laboratory (MBL) who has spent 17 summers at Toolik.

R. G. WHITE/UNIVERSITY OF ALASKA, FAIRBANKS

**Tundra dacha.** Toolik's new labs will accommodate more researchers and better chemical analyses.

Peterson and his colleagues are willing to brave the rudimentary facilities and forbidding isolation because they think Toolik, an Eskimo word for the yellow-billed loon, is one of the best places on Earth to study a pristine ecology that may be on the brink of a major upheaval. Most global climate models are now predicting that over the next two centuries, rising levels of greenhouse gases such as carbon dioxide and methane, spewed into the atmosphere by industry, agriculture, and transportation, could raise Arctic temperatures by as much as 6 degrees Celsius in the summer and 12 degrees in the winter—several times that predicted for the temperate climes. "These areas are going to be the bellwethers of global warming," says University of New Mexico stream ecologist Cliff Dahm, who this summer studied the interaction between ground water and surface water in two Toolik tributaries.

But the scientists may not have long to gather their data. The Arctic's climate may already be changing: The average surface temperature of Toolik Lake during the summertime has risen nearly 3 degrees in the past 15 years. Although nobody knows whether the region is experiencing global warming or merely a short-term temperature blip, the heat already appears to have triggered an effect. The Arctic tundra, for thousands of years a carbon "sink," has begun in the past decade to release carbon dioxide as warmer air dries the tundra and causes better aeration of the upper soil layers. "This is almost assuredly tied to the temperature increase" at Toolik, says San Diego State University ecologist Walter Oechel. And researchers fear that more pronounced warming could increase plant production as well as thaw millions of acres of permafrost, releasing an unknown portion of the estimated 180 billion metric tons of carbon in Arctic soil and fundamentally altering Arctic ecosystems.

However, this scenario appears to be more complex than researchers have envisioned. New data from Oechel's team published earlier this month (*Nature*, 6 October, p. 500) found that tussock plots at Toolik did release carbon dioxide in the presence of elevated atmospheric levels of the gas. However, when temperatures at the plots were raised by a few degrees, carbon dioxide loss from the ecosystem was much less. The findings, taken over 3 years, suggest that regions of the Arctic that remain moist, like the experimental plots, may release less carbon than predicted if global warming were to occur. But climate models also predict that much of the tundra is expected to become drier than the experimental plots and, thus, more likely to release carbon dioxide. More sustained experiments, Oechel says, are needed to understand the delicate Arctic ecosystems.

Ecologists are discovering just how delicately balanced those ecosystems are. A decade ago, a team led by Peterson and John Hobbie, co-director of MBL's Ecosystems Center, began adding small amounts of phosphorus to the Kuparuk River, a stream that meanders out of the foothills of the Brooks Range. By the end of the summer the researchers saw the river "turn from bare rocks to a thick felt of diatoms," recalls Peterson. The researchers concluded (*Science*, 27 September 1985, p. 1383) that this minor perturbation had set off an ecological chain reaction. The phosphorus, acting as a fertilizer, spurred the growth of algae, which in turn nourished a burgeoning insect population that by summer's end had fattened the stream's grayling fish population.

This summer, 120 scientists and students conducted research at an 11-year-old field station on the south shore of Toolik Lake, a successor to an abandoned site on the north shore. The camp, owned by the University of Alaska, Fairbanks, and operated by the university's Institute of Arctic Biology, dwarfs in size the handful of other U.S. Arctic research encampments and is the largest of five major Arctic field stations in the world. Moreover, activity at Toolik has exploded in the past decade: The number of "user days," a measure of time researchers have spent at the site, has increased 65% since the 1984 field season.

That growth has been made possible by a growing commitment to the research from NSF. In August, NSF officials dedicated about $800,000 in new lab buildings that double the camp's capacity. The labs also give Toolikers, for the first time, an animal facility and a "clean environment" for conducting sensitive chemical analyses. This construction boom is funded by the agency's expanded $14-million Arctic Systems Science program, and NSF is weighing a request from some users to make Toolik the nation's only year-round Arctic camp.

Toolik is also one of 18 Long-Term Ecological Research (LTER) sites supported by NSF (*Science*, 15 October 1993, p. 334). Each site receives a 6-year renewable grant to conduct experimental research as well as to develop an ecological baseline, data that are crucial for tracking environmental change. The importance of baseline data was made clear 5 years ago, when the *Exxon Valdez* spilled 11 million gallons of oil into Prince William Sound in southern Alaska. Because ecologists knew so little about the region, it was difficult to assess the damage from the oil spill. Ecologists want to avoid a similar dearth of data about northern Alaska. "Fifty years from now, people are going to be scrutinizing Toolik's baseline data closely," says John O'Brien, an aquatic ecologist at the University of Kansas.

If scientists achieve their goal of understanding Toolik's ecological processes, their accomplishment will be all the more impressive in light of the difficulties in conducting research at Toolik. Built in 1970 as a temporary camp for workers laying the Dalton Highway from Fairbanks to the Arctic Ocean oil fields in Prudhoe Bay, the site later became the summer home for a dozen scientists who practiced a rustic brand of research. "Bears would sneak into camp and tear down tents," recalls University of Cincinnati zoologist Michael Miller, the only Toolik scientist to have spent each of the last 20 summers doing research in the Arctic. Outfitting and running the camp left little time for experiments. "In the first few years, we did the science between cooking and doing dishes," says Peterson.

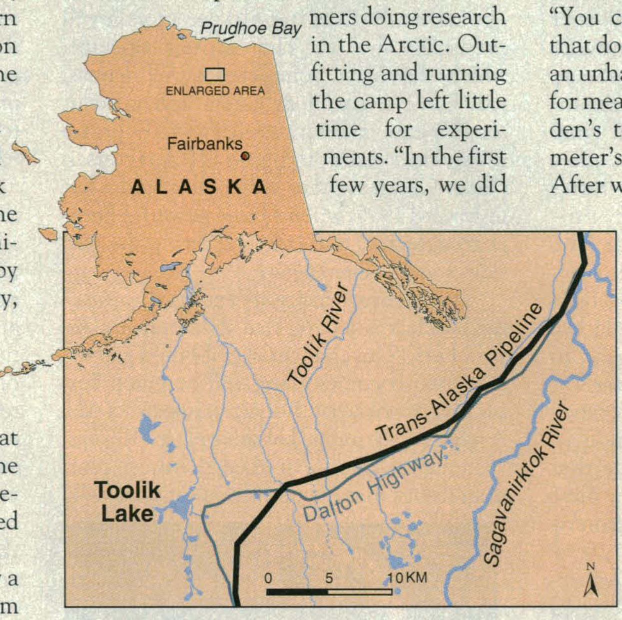
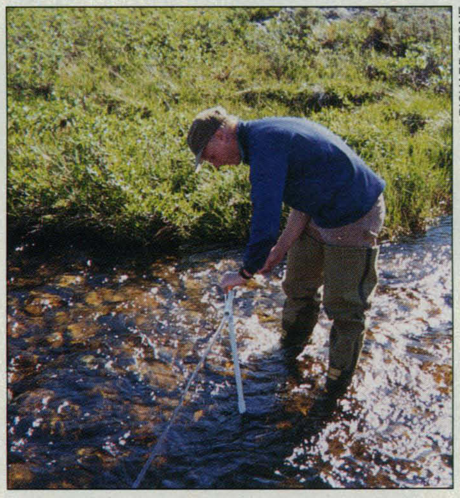


ILLUSTRATION: C. FABER SMITH

Although the climate and the distance from civilization still make research difficult, conditions have improved enormously in the past two decades. The camp now has a full-time manager, cook, and maintenance person. People eat well: Transportation costs from Fairbanks to Toolik are so high that the marginal cost of luxury foods seems trivial. (On the Fourth of July, for example, researchers traditionally binge on lobster tails, crab legs, and shrimp.) And the northern exposure does provide one major advantage: The midnight sun makes it possible to do round-the-clock field work. Indeed, "you can kill yourself doing research 24 hours a day, 7 days a week," says University of New Hampshire biogeochemist Breck Bowden.


RICHARD STONE

**An extreme stream.** Graduate student John Morrice loads a Toolik tributary with a dye to map stream flow.

Given the 3-month-long field season, there's plenty of incentive to put in long hours—and there's little margin for error. "You can't come up here with something that doesn't work," says Bowden, who recalls an unhappy experience last year with a meter for measuring dissolved oxygen. When Bowden's team got to the site, several of the meter's probes "failed completely," he says. After wasting 2 weeks on the problem, Bowden recalls, the researchers were finally able to collect data by reprogramming the meter.

Certain procedures taken for granted elsewhere can become major headaches at Toolik. "A lot of things we do in the field are extra hard," says Hobbie, a veteran Arctic researcher who in 1960–61 overwintered with his wife in the Arctic National Wildlife Refuge, in the northeast corner of Alaska, living in a cabin heated only by a kerosene stove. For instance, Hobbie says, researchers were stymied at first by the difficulty of pounding stakes into the ground to support weirs—fences that separate fish populations in streams and lakes. The task was particularly challenging because permafrost lies less than a foot below the surface. "Finally, we found parts of an old steam shovel and used those to pound the bars in," Hobbie says. Even now, he says, researchers are unable to construct certain kinds of weirs in fast-moving streams because the pooled water melts the permafrost holding the weir in place.

Despite these obstacles, outside scientists laud the work being done at the site. "They do quite a remarkable job," says University of Washington aquatic ecologist Robert Wissmar. He says he's particularly impressed with a computer model designed by MBL's Peterson to trace the passage of nitrogen from species to species in the Kuparuk River food web. Peterson's work underscores the broad significance of Toolik research, global warming or no. His model, developed from data on the relatively simple Kuparuk ecosystem, is now being tested at LTER sites in North Carolina and Oregon.

This and other work now under way leave scientists expecting great things from the site. "No doubt, Toolik will be a very important place over the next decade," says Dahm, now serving as an NSF program manager. For many scientists, the prospect is exhilarating. "Out here you just feel energized," says University of Minnesota, Duluth, ecologist Anne Hershey, a longtime Tooliker.

–Richard Stone