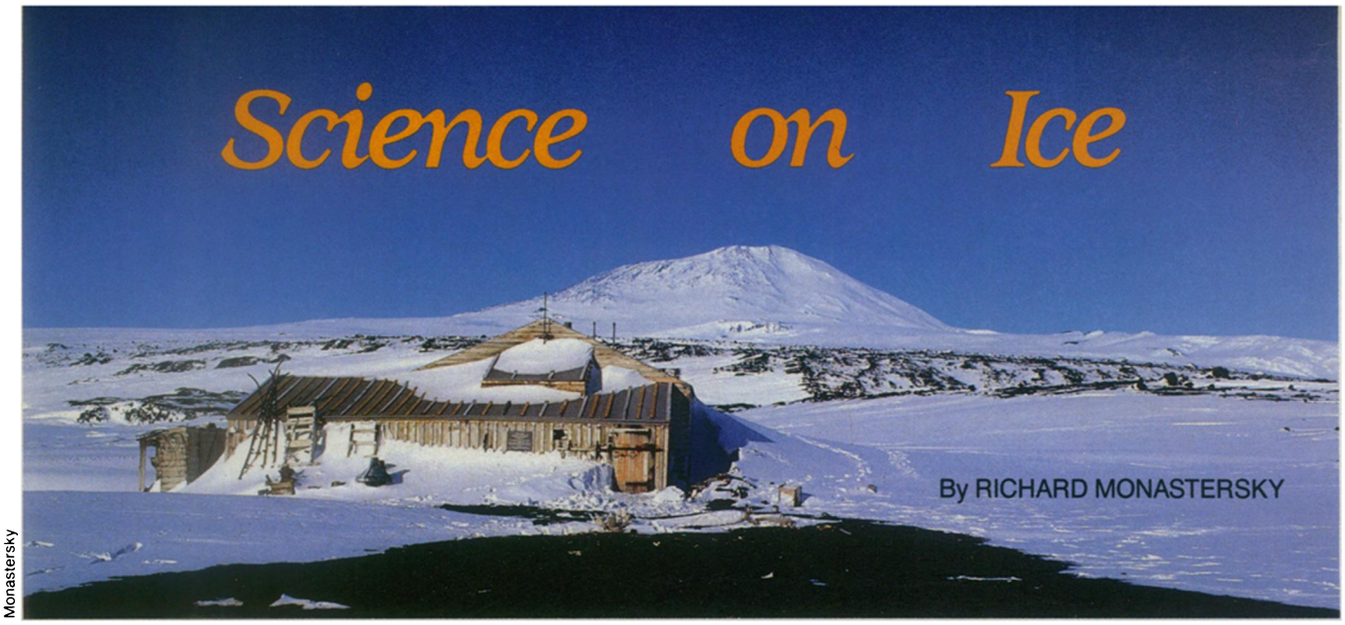


Monastersky

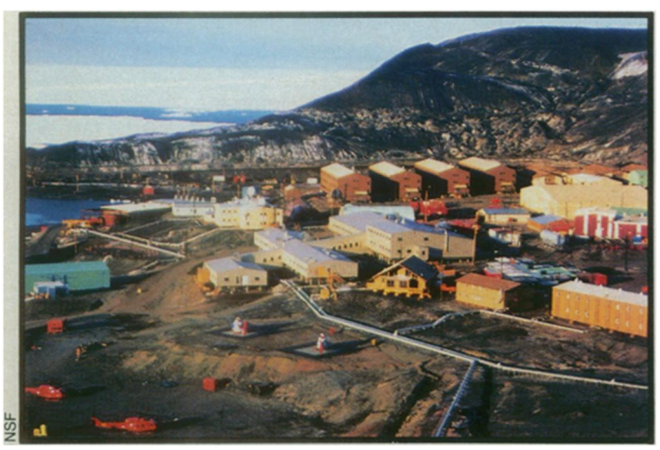
Researchers fear Antarctic studies face a chilling future

McMurdo Station, the "Gateway to Antarctica," could never lay claim to the word beautiful. Erected on an island along the coast of the frozen continent, this bustling frontier town consists of 90 utilitarian buildings connected by streets of slushy, black mud. A raised network of heated pipes snakes around the dorms and offices, carrying water and sewage from the swollen summertime population of 1,200 people. Because of a shortage of indoor storage space, construction materials and waste drums sit outside in rows, awaiting further use or the arrival of a ship to transport them away in late summer. In this harsh climate, the spartan station lacks even the hint of vegetation, save for the green paint adorning a few buildings.

Despite its industrial feel, the United States' biggest base in Antarctica actually looks a lot better now than it has in the past, when garbage, old machinery, and drums of toxic waste were blithely bulldozed down the hill and into nearby Winter Quarters Bay. Decades of such environmental abuse earned McMurdo the dubious distinction of being one of the world's most polluted spots, sitting on a continent largely untouched by humans.

The National Science Foundation (NSF), which runs U.S. operations in Antarctica, embarked three years ago on a $30 million program to atone for its past environmental sins in McMurdo and at other sites on the continent. "If you think McMurdo is ugly, talk to someone who was here three or five years ago," says David M. Bresnahan, the chief NSF representative in McMurdo. Return visitors to McMurdo do notice the difference. Even the environmental groups that first exposed the pollution problems acknowledge that NSF has made great strides toward cleaning up its domain down south.

Yet the changes in Antarctica are just beginning. All nations must face some radical shifts in the way they do business on the icy continent, because events of the past few years have conspired to focus international attention on Antarctica as never before.



NSF

Established in 1955, McMurdo Station is the largest base in Antarctica. Winter Quarters Bay, seen at left behind buildings, is a natural anchorage used by Robert F. Scott in his first expedition in 1902.

Early accommodations (above): From 1911 to 1913, the men of Scott's last expedition lived in this hut at Cape Evans, 25 kilometers from Winter Quarters Bay. Mount Erebus, an active volcano, stands in the background.

In 1989, even as environmental organizations were attacking NSF for pollution at the main U.S. base, an Argentine supply ship, the *Bahia Paraiso,* ran onto rocks near Palmer Station, a U.S. outpost on the opposite side of the continent from McMurdo. The foundering vessel spilled 250,000 gallons of diesel fuel into coastal waters where scientists had been studying populations of native animals.

With penguins and fish fouled by the fuel, the spill pointed out all too dramatically the potential dangers of bringing humans into the pristine Antarctic world. The *Bahia Paraiso* incident was also significant because the ship carried 81 tourists, who have flocked to Antarctica in rapidly increasing numbers each year. The tourist boom has raised concern that such visitors will exacerbate pollution problems, harm wildlife, and upset scientific research on the continent.

In the most important of the recent developments, 26 nations active in the Antarctic concluded in 1991 a treaty in which they pledged to regulate their conduct in order to protect the region's fragile ecosystems. Congress and the Clinton administration are currently drafting U.S. laws that would enforce the treaty, called the Protocol on Environmental Protection.

The specter of new regulations haunts many scientists. While they welcome efforts to preserve the Antarctic, researchers fear that a backlash against the excesses of the past will unduly hamper legitimate scientific work.

Antarctica is the one continent on Earth where science reigns. Research has ruled over the icy landmass since 1957, when a dozen nations collaborated in a wide array of geophysical experiments and established more than 40 new observation stations there. In 1959, the success of that effort led the 12 countries to conclude the Antarctic Treaty, which prohibits military actions on the continent and establishes the freedom to pursue scientific investigations there.

A visit to McMurdo Station and the South Pole Station late last year revealed that U.S. research there is indeed thriving in a number of fields. While critics in years past have attacked Antarctic science as being second-rate, NSF has improved the quality of research, according to participants and observers of the U.S. program, which this year cost $221 million, or roughly 8 percent of the overall NSF budget. Increasingly, investigators are taking advantage of the unique Antarctic environment to tackle problems that reach beyond the polar regions. While glaciologists trace hints of past climate change, atmospheric chemists gauge the damage to the global ozone layer and astronomers listen to the faint echoes of the Big Bang.

Even during the so-called heroic era, science played a role in explorations that opened up the harsh southern world. When British explorer Robert Falcon Scott and his companions set off from the McMurdo region in late 1911, their foremost goal was to plant the first flag at the geographic south pole some 1,300 kilometers away—a race they lost by a month to Roald Amundsen of Norway. But Scott also felt the expedition had a scientific purpose that helped justify the journey's risk. On the trip back from the pole, when the explorers were running short on food, fuel, and endurance, they nonetheless spent precious time collecting 35 pounds of geologic samples, which they added to their sleds and "man-hauled" on foot across the snow. Scott and his companions never made it back to their ship; they died just 18 km from a depot of supplies that could have saved their lives.

When members of the recovery party finally reached the frozen bodies eight months later, they found the rock samples the struggling men had refused, perhaps foolishly, to cast aside. "They had stuck to these to the very end, even when disaster stared them in the face and they knew that the specimens were so much weight added to what they had to pull," wrote Edward L. Atkinson, leader of the recovery party.

Since Scott's death, countries have certainly harbored interests in Antarctica that go beyond science. In the first half of this century, seven nations staked claims — sometimes overlapping — to particular sections of the frozen landscape, recognizing that the ice might cover potential mineral resources. Later, as the Cold War raged, the United States and the Soviet Union sought to counterbalance each other's presence on the ice. The U.S. Navy remains active in Antarctica today, providing much of the logistical support for the three U.S. bases, although it seeks to reduce its role.

Whatever their underlying motives, nations working in Antarctica during the last three decades have maintained that scientific pursuits are the predominant reason for their activities on the continent. The 1991 protocol makes explicit the primacy of science when it designates Antarctica as "a natural reserve, devoted to peace and science." It also extends for 50 years a previous ban on mineral exploration.

The concept of Antarctica as a science reserve makes most researchers happy. At the same time, however, the protocol sets strict guidelines for protecting the Antarctic environment, and this will force a change in behavior among scientists and the personnel who support them. Here is where the worry arises.

Under the 1991 protocol, nations must perform impact assessments on any proposed activities, and if those actions might have lasting or significant effects on the environment, the nations proposing them must circulate assessment reports to other countries for approval. Moreover, Antarctic visitors must ship home most forms of waste they produce, with the exception of materials that can be burned in incinerators and human wastes, which may be discharged into the sea. Nations must also monitor the environmental impact of their activities.

Late last year, the National Academy of Sciences convened a Committee on Antarctic Policy and Science to examine the future of research on the southern continent. At a committee meeting in February, scientists from various disciplines suggested that the protocol might prohibit them from performing certain experiments or make it much more difficult to obtain approval to perform them.

At present, most Antarctic researchers—with the exception of those studying wildlife—do not need permits to conduct their experiments. But physicists, glaciologists, and others worry that they may soon face strict permitting procedures that will add to the already heavy logistical loads they bear in order to work in so remote a place. Because weather restricts outdoor studies to a four-month window each year, scientists fear they will miss research opportunities while awaiting approval of their permit requests.

"Certainly, flexibility in science is absolutely necessary," says committee member Donald B. Siniff, a biologist at the University of Minnesota in Minneapolis. "That's a concern I have with the environmental protocol. You cannot detail in a permitting process exactly what you're going to do in the field. You are there and things happen. And you need to react to those things. Sometimes you can [react] under your permit, and sometimes you cannot."

Theodore J. Rosenberg, a physicist at the University of Maryland in College Park, suggests that the protocol's prohibitions on waste disposal could dramatically handicap some scientific projects. For instance, the ban on disposing of batteries, if enforced in all circumstances, would prevent researchers from

At the Amundsen-Scott South Pole Station, meteorologists release a balloon that will carry an ozone-sensing instrument into the stratosphere.

Monastersky

Antarctic pollution: How bad is it?

Winter Quarters Bay has a long and checkered record in the annals of Antarctic history. When Robert Falcon Scott made his first trip to the frozen south in 1902, this natural harbor provided a safe anchorage for his ship *Discovery* during the expedition's two-year-long stay on the ice. Ninety years later, Winter Quarters Bay is known as one of the most polluted spots on the continent.

Located next to modern McMurdo Station, the bay served as a dumping ground for everything from fuel drums to scrap metal until the late 1970s. Analyses show that the waters and bottom sediments there are contaminated with high concentrations of hydrocarbons, PCBs, and other toxic chemicals. Yet the same studies also show that the polluted area remains quite small, essentially limited to the confines of the bay itself, which measures only 9 acres.

"Winter Quarters Bay is as polluted as the harbor of any city, but it's small enough that a good batter could hit a baseball out of it," says John Oliver, an ecologist with Moss Landing (Calif.) Marine Laboratories.

Studying the bottom-dwelling communities in the bay, Oliver and his colleagues have found that pollution has driven away most of the organisms typically found in this ecosystem, leaving the region to be colonized by opportunistic "weedy" species such as polychaete worms. Sites as close as a kilometer away, though, are nearly pristine, the researchers report in the February MARINE POLLUTION BULLETIN, a special issue devoted to the Antarctic environment. The National Science Foundation is now considering options for tackling the mess in the bay.

In the same journal, two research groups discuss the spread of sewage pumped into McMurdo Sound in front of the station. James P. Howington of the Monterey Bay Aquarium Research Institute in Pacific Grove, Calif., and his co-workers traced the distribution of coliform bacteria, a type present in human intestines. They found that water containing significant concentrations of these bacteria (up to 523 coliforms per 100 milliliters) sometimes reached the intake pipe that carries seawater up to a desalinization plant, which produces potable water for McMurdo. A study by a second group confirmed that traces of the sewage reach the seawater intake pipe.

Gordon A. McFeters of Montana State University in Bozeman, who organized the coliform study, says that although coliform concentrations at the intake pipe can reach "fairly high levels at times," studies of McMurdo's tap water indicate that the desalinization process kills the bacteria. He wonders, however, whether intestinal viruses in the sewage might survive the treatment process. At a congressional subcommittee hearing in February, Peter E. Wilkniss, past director of NSF's Office of Polar Programs, said he believes U.S. Antarctic stations will need to start processing their sewage to remove all solid waste before it enters the ocean.

Studies to date suggest that most pollution from human activities in the Antarctic affects only the neighborhood around the scientific bases. But scientists and environmental groups caution that even such localized pollution can harm some science projects. For example, aircraft flights over the continent and the incineration of waste at bases emit gases and heavy metals that could hamper efforts to discern the amount of pollution coming from other continents, says Eric Wolff of the British Antarctic Survey in Cambridge.

Although incinerators are permitted under the protocol, NSF's use of one at McMurdo Station has drawn considerable criticism from environmental groups. In 1991, the Environmental Defense Fund sued NSF, seeking an injunction that would prevent the foundation from incinerating waste before completing an environmental impact statement, which is required under the National Environmental Protection Act (NEPA).

Later that year, the U.S. District Court for the District of Columbia ruled that NEPA did not apply to Antarctic activities because they occur outside the United States. But in January 1993, the U.S. Court of Appeals for the District of Columbia ruled that NEPA did indeed apply. The appeals court sent the case back to the district court to decide whether NSF has adequately assessed the impact of incineration.

Although officials at NSF had hoped to appeal the recent ruling, the Clinton administration decided in March not to seek a rehearing. In late March, NSF temporarily shut down the McMurdo incinerator, saying it will review new data and consider its options for disposing of food waste.

With the reduced population in McMurdo at this time of year, NSF can stockpile the waste, says Lawrence Rudolph, NSF's acting general counsel. But officials do not have long to resolve the issue. In six months, the austral winter will end and McMurdo's cozy population of 200 will swell as 1,000 more waste-producing people arrive at the station. *—R. Monastersky*

Monastersky

Bales of crushed cans in McMurdo wait to be transported off the continent. In an effort to cut pollution, NSF has established a comprehensive recycling program.

launching balloons to study the ozone hole because the instruments on board include batteries, and researchers typically cannot recover them once they fall to the ice.

Brian L. Howes, from the Woods Hole (Mass.) Oceanographic Institution, projects that stricter environmental regulations could drive the best investigators away from Antarctic science, lowering the general quality of research there.

Investigators also wonder whether basic scientific research will lose funding because the protocol requires nations to launch potentially expensive studies to monitor their pollution and its effect on the environment. Coupled with the new requirement on removing and processing waste, these developments will drive up the cost of doing science in Antarctica.

The need for additional funding comes at a bad time, from the perspective of international politics. "The end of the Cold War has led to speculations that the amount of money spent on Antarctic research will drop because the need to maintain a presence there is less important now than it once was," says Lee A. Kimball, a specialist in Antarctic law and policy in Washington, D.C.

If the U.S.-Soviet rivalry helped inflate Antarctic science funding in the past, researchers now must face new pressure to explain why their work is necessary. "People who are doing Antarctic science are going to have to justify it on the grounds of science: Is it significant science? I don't think that has always been the case in the past, when the presence issue was more important," Kimball says.

As researchers fret over the future of their work in Antarctica, environmentalists contend that scientists have worried themselves unnecessarily over questions of upcoming regulations.

"I think a lot of the concern is unwarranted," says Beth C. Marks, director of the Antarctica Project in Washington, D.C. For instance, with regard to a prohibition

on balloon-borne batteries, she says: "That's unreasonable and nobody is going to be unreasonable." Marks suggests that the nations that have signed the protocol will address such issues in upcoming meetings.

For U.S. scientists, the protocol's practical impact on research depends largely on the legislation Congress enacts to enforce the new treaty. The Clinton administration has yet to decide on the law it desires, and it will not fashion a position until late spring at the earliest, says Lawrence Rudolph, the acting general counsel for NSF. Rudolph testified in late February before the House Subcommittee on Science, chaired by Rep. Rick Boucher (D-Va.).

One of the key undecided issues is which federal agency will regulate U.S. activity in Antarctica. Boucher has introduced a bill that would give NSF principal responsibility for enforcing the protocol provisions, with some oversight provided by a presidential commission. This approach drew praise from scientists at the congressional subcommittee hearing and at the meeting of the National Academy of Sciences committee. They believe NSF will limit the red tape and regulations faced by scientists because it has an express interest in seeing results from the projects it funds.

Yet environmental groups and some legislators argue strongly that regulatory authority should rest with another agency, such as the Environmental Protection Agency or the National Oceanic and Atmospheric Administration. That arrangement, they say, would allow better oversight of NSF's actions on the ice, ensuring that NSF does not repeat problems of the past, when it regulated its own activities.

"We cannot ignore that years of environmental neglect and self-regulation have caused the very environmental problems that NSF is tackling today," Susan Sabella of Greenpeace USA, Inc., in Washington D.C., told the subcommittee.

Sabella and others question whether NSF has the expertise or motivation to issue the environmental regulations needed to enforce the protocol. She points out that although Congress called on NSF back in 1979 to issue environmental regulations concerning its Antarctic activities, the foundation is only now doing so.

As evidence that NSF should not regulate itself, Bruce S. Manheim of the Environmental Defense Fund in Washington, D.C., argues that NSF failed to perform an environmental impact assessment before it blew up some 70 pounds of aging toxic chemicals using 4,000 pounds of chemical explosives in December 1991. Manheim grants that blasting may indeed have been the best method for disposing of the unstable chemicals. But he criticizes NSF for not having produced an impact assessment before taking the action.

Erick Chiang, manager of polar operations for NSF, says NSF had started an assessment before the blast, but a mistake led workers to set off the explosion on the ice several miles from McMurdo before the study was completed.

Whatever legislation eventually emerges, NSF's Antarctic activities will undoubtedly face increased scrutiny. At the same time, the cost of doing research in Antarctica will climb as nations enforce the provisions of the protocol. During the February hearing, NSF Deputy Director Frederick M. Bernthal announced that the foundation would require an additional $66 million to improve U.S. operations to a point where they produce minimal effect on the environment.

While science is still king in Antarctica, it now must get used to sharing the throne with environmental concerns. Peter E. Wilkniss, past director of NSF's Office of Polar Programs, summed up the challenges last September at an orientation for scientists preparing to head south.

"Antarctica will never be the same," he warned. "The old freewheeling days are over. There are more regulations in Antarctica. You will be held more responsible." □

Letters continued from p.227

Composting: A costly cure?

"Cleaning Up Compost" (SN: 1/23/93, p.56) reminded me of my very earliest memory. I was barely able to reach the top of the kitchen trash can. As I threw something in, my mother said, "That's not garbage, that's trash." Many years later when I asked her what it meant, she said that my father, an officer stationed at Hickham Air Force Base from 1946 to 1948, sold the post's garbage to local pig farmers. Everyone on the post was required to separate garbage (food waste) from other trash. I don't know anything else about the practice except that it was profitable.

It does prove, however, that, under certain circumstances, Americans will separate their trash, recyclables, and edible or compostable garbage.

Rosemary M. Killen
College Park, Md.

Your article clearly testifies to the incredible lack of economic viability of almost all of the recycling schemes thus far presented. For example, you state that the Connecticut Agricultural Experiment Station employed the output of the Procter and Gamble research program to increase crop yield.

Did anybody, anywhere consider the magnitude of the problem that would result from actually using that stuff? The New Haven group used the composted material at the rate of 50 tons per acre. For a normal Midwest 640-acre farm, that comes to 32,000 tons. If a farmer living within five miles of the railroad used a 4-ton truck to haul the stuff to his farm, he might make a round trip, including loading and unloading, in two hours. Since he must make 8,000 round trips (80,000 miles), he could achieve the hauling task in 16,000 hours, or slightly under two years.

Of course, he would have to work day and night all 365 days of the year, without letup, and would use about $12,000 worth of gasoline. He would also have to pay for the material, its railroad charges, and the job of spreading it over the fields.

John P. Kelly
Albuquerque, N.M.

Memories of circulating sound pulses

While it was interesting to hear that a working general-purpose optical computer has been built ("Juggling at the speed of light," SN: 1/23/93, p.63), the statement that its "most striking feature is that no data are ever stored – even temporarily – in particular locations . . . as they would be in an electronic computer. Instead, information circulates as light pulses through optical fiber loops," seems to imply that memories using circulating pulses are new and unique to optical computers.

The second general-purpose electronic computer (EDVAC, designed in 1946 though not working until 1952) used exactly this kind of data-storage approach, except that it used mercury acoustic-wave delay lines storing data as circulating sound pulses instead of optical fibers storing data as circulating light pulses. Many other early electronic computers also used circulating pulse memories (EDSAC in 1949, SEAC in 1950, the first UNIVAC in 1951, and others).

Circulating pulse memories have long been obsolete in electronic computers because they limit the speed at which the machine can get the data it needs.

It seems to me that optical computers are closer to the electronic computers of the early 1950s than the mid-1960s.

R. Tim Coslet
Sunnyvale, Calif.

More animals recognize rotation

In "Baboons offer glimpses of left-brain brawn" (SN: 1/23/93, p.54), you summarize research by Hopkins and colleagues on baboon image perception and claim that their work provides the first demonstration that a nonhuman animal can recognize images that have been rotated.

There is no question that the work reported is important. However, other studies have also reported evidence of recognition of rotated images. For example, Richard Herrnstein has demonstrated that in pigeons, reaction time for image recognition (that is, categorization) is unaffected by rotation. And Perrett and colleagues have shown that in rhesus macaques, as in humans, upright faces are processed more rapidly than inverted faces.

In general, therefore, there appear to be a number of commonalities between humans and nonhumans with regard to image perception. This work is exciting because it provides us with a better understanding of the evolutionary precursors of human cognition.

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