

# Water shortage pits man against nature

## San Francisco

HEAVY rains and snows fell in California last week, bringing a welcome respite to this state that has now suffered five years of drought. As welcome as it was, however, the precipitation will not go very far to restore the withered landscapes, dry reservoirs and fallow farmland that have become all too common in California.

In the face of nature's adversity, engineers and planners are now turning to scientific and technological solutions to the water shortage. Instead of praying for rain, they are considering such options as seeding clouds over the Sierra Nevada mountains, desalting Pacific Ocean seawater and piping fresh water thousands of miles from Alaska.

Although it has rained little in California in recent years, the drought is not due to a lack of storms, says Tom Henderson, president of Atmospherics, Inc., a cloud-seeding company in Fresno.

The drought years have actually produced 80 per cent of the number of storms of normal years, he says. Instead, the problem is that the storms in wet years were generally taller, thicker, longer-lasting and much higher in liquid water content than those in the drought years. So, while some regions have seeded clouds for years to increase rainfall, this winter several more communities have turned to various cloud-seeding techniques to enhance the weaker storm systems.

Monterey County is paying about \$130,000 to send airplanes into every cloud that has the potential to produce rain for the area this season. The planes release tiny crystals of silver iodide which, at appropriate temperatures and sites within the cloud, act as nuclei for ice crystals, which later become rain or sleet or snow. Monterey County dis-

trict meteorologist John Stremel finds the initial results of the cloud-seeding programme "very encouraging", although actual increases will not be calculated until the end of the season.

Over the high hills of Santa Barbara, cloud seeding has led to a 25 per cent increase in rainfall, with rain falling earlier during storms and more intensely. Most efforts do less well, Henderson says — the process typically yields a 5–15 per cent increase in annual precipitation.

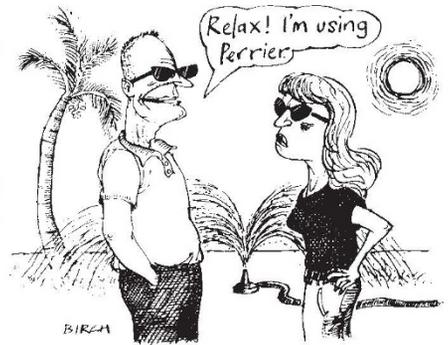
Silver iodide, used in 95 per cent of all cloud-seeding efforts worldwide, is the material of choice for rain-making, but researchers are testing a variety of other materials. Dry ice, for example, can be used when cloud-top temperatures are between  $-4^{\circ}\text{C}$  and  $-5^{\circ}\text{C}$ , warmer than the conditions for silver iodide. And Atmospherics is experimenting with different organic compounds that modify the seeding agents for use in different cloud conditions.

Henderson has also seeded a few clouds with the bacterium *Pseudomonas syringae*, which is usually found on plant leaves, where it nucleates ice crystals. Atmospherics scientists are still optimizing its use in laboratory tests, but they have found it can form crystals at the relatively high temperature of  $-0.5^{\circ}\text{C}$ .

In the Plumas National Forest, the state Department of Water Resources and the US Forest Service are developing an experimental ground-based cloud-seeding programme that uses propane to trigger precipitation. Propane has been used by the US Air Force to clear fog at airports, but this project is expected to mark its first use in cloud-seeding. Courtland Bennett of the US Forest Service says the plan calls for ten seeding stations on mountain ridges over Feather River to

release liquid propane into the atmosphere at cloud level in the hope of generating additional runoff into reservoirs of the State Water Project.

Some California cities have begun to look toward a source of almost unlimited water: the sea. Although desalination plants have operated for years in Middle Eastern countries, and even in Florida in the United States, they have traditionally been considered too expensive for use in California because they require huge amounts of en-



ergy.

But the city of Santa Barbara has decided to tolerate the high cost in return for a guaranteed water supply. In that central coast city, where the two main water reservoirs are just 12 and 14 per cent full, officials say construction of a desalination plant will begin by midsummer. The city currently delivers water to its customers for \$200 per acre-foot, but it will pay contractors \$1,900 per acre-foot for the desalted water when it becomes available in a year. (An acre-foot of water is 326,000 gallons, or enough to supply a suburban family of five for a year.)

Desalination plans are also under scrutiny

## Drought threatens Californian bird populations

CALIFORNIA'S drought is putting at risk several populations of the state's endangered and threatened species, including a pioneering pair of bald eagles and several types of fish.

At Lake Cachuma in central California, US Fish and Wildlife Service biologists are worried about a breeding pair of endangered bald eagles. Although this part of the state was once a common breeding ground for the eagles, the birds retreated north in the 1950s, and it was only two years ago that this pair became the first to recolonize the Lake Cachuma territory. But the lake, which supplies water to Santa Barbara, is just 14 per cent full, and biologists fear that if it loses its fish populations, it will also lose the pair of resident eagles as well as 15 other eagles that winter there before returning to their northern nesting grounds.

With only 2,000 breeding pairs of eagles in the continental United States, it is important to encourage the raptors to

colonize many areas so that a local disaster does not destroy the species, says Robert Mesta of the Fish and Wildlife Service. The Lake Cachuma pair "represent the seed of a Southern California population", he says, and their progeny will probably return to the lake.

Further north, in the Sacramento River delta, winter-run chinook salmon are in danger. For a number of reasons, the salmon population, which runs up the Sacramento River to spawn, has been diminishing for several years and last year reached a record low of 441. Now biologists are worried that after upstream water is diverted by federal water projects to farms and cities, the river will be too warm for the fish. Water temperatures over  $56^{\circ}\text{F}$  ( $13.3^{\circ}\text{C}$ ) are deleterious to the salmon, and temperatures over  $60^{\circ}\text{F}$  ( $15.5^{\circ}\text{C}$ ) are lethal.

Officials with the federal Central Valley Project are now studying ways to change water delivery plans or lower the river-

water temperature to spare the winter-run salmon. The species is protected under the Endangered Species Act.

But many other species of fish are also in danger, and are not yet covered by the Endangered Species Act, says Peter Moyle, professor of wildlife and fisheries biology at the University of California at Davis. Moyle recently completed a survey of all the native fishes in the state and found that of the 113 species, 74 were in need of special protection. Six of those species had become extinct since 1957, and 16 were formally listed as endangered. Most of the damage had been done by water diversions and the introduction of predatory game fish, but for some species the drought could be the final straw. Moyle predicts that with another year of drought the state could add delta smelt, coho salmon and spring-run chinook salmon to the list of species that have disappeared from California waters. E.S.

FRANCE

## Budget cuts for research

### Paris

FRENCH researchers will have to tighten their belts over the next few years as a result of a significant slowing in the nation's economic growth, made worse by the cost of the Gulf War.

Initially forecast at 2.7 per cent, growth this year is running at 1.5 per cent, mostly because of reductions in rates of value-added tax to bring France in line with its European neighbours.

Last week, the finance minister announced cuts of around FF1,000 million (\$189 million) in the FF48,700 million 1991 civil research budget. But cancelled programmes whose cost was to be spread over several years mean a further FF2,400 million will be lost. Instead of progressing by 6 per cent, as promised, the civil research budget will now be only 0.5 per cent ahead of inflation, currently estimated at 2.5 per cent.

At the ministry for research and technology (MRT) there is a mixture of relief and concern. Denis Plantant, budgetary adviser to research minister Hubert Curien, says that the cuts are "less than we expected initially".

This year, MRT's budget has been cut by FF200 million (0.8 per cent), although when cancelled long-term investments are taken into account, the figure is FF349 million. But, adds Plantant, the effects on the re-

search organizations (such as the Centre National de la Recherche Scientifique, CNRS) will be "not negligible".

These organizations, responsible for most of the nation's basic research, will be especially affected by cancelled long-term programmes, while their budgets for laboratory running costs are also to be reduced by 3 per cent. CNRS alone will lose FF64 million this year (out of a FF11,100 million annual budget), with more than FF102,000 million cut from long-term investments in equipment and construction.

Although the research organizations are to bear the brunt of the new cuts, the government's priority areas — industrial research and the universities — have been largely protected. University research and teaching have not been touched, while spending on industrial research is down FF40 million out of a total budget of FF4,000 million.

France is a major contributor to European technology programmes and to the European Space Agency, but the cuts announced in these sectors are minimal. "France will be able to honour her commitments", says Plantant.

But one official close to the research minister says that French spending on space projects — including the Hermes space shuttle and Ariane 5 launcher — will come under the microscope again in "late spring or early summer".

Peter Coles

### BRITISH TECHNOLOGY GROUP

## Universities considering a buy-out

### London

BRITISH universities, anxious to protect their £13 million annual income from the government-owned British Technology Group (BTG), may try to buy a stake in the company when it is sold into the private sector.

BTG is Britain's largest technology transfer organization. In return for a share in any commercial profits, BTG helps inventors with patent applications, negotiates licence agreements with manufacturing companies, and may even provide funding for research and development (R&D). A government bill to privatize BTG is now passing through parliament (see *Nature* 349, 272; 24 January 1991).

Although welcomed by senior BTG management, the move was attacked by the opposition Labour party, which argues that private ownership would restrict BTG to backing inventions that are likely to give commercial returns in the short term.

The universities receive about £7.5 million a year from BTG in R&D grants, plus some £5.5 million in royalties from BTG-patented inventions. The Committee of Vice-Chancellors and Principals (CVCP) considered the likely impact of the privatiz-

ation at a meeting earlier this month, where several vice-chancellors argued that a buy-out is the best option to protect the universities' long-term financial interest in BTG.

But BTG's price tag, at £35 million, is more than the financially stretched universities can afford. CVCP staff are now investigating the possibility of putting together a consortium to share the cost of a BTG buy-out, making discreet advances to other interested bodies, including large British research foundations.

A university-led buy-out would ease the concerns of university-based inventors, but some resentment over the government's handling of the privatization would remain. Peter Mansfield, from the University of Nottingham, who in the early 1970s developed Magnetic Resonance Imaging, one of the outstanding commercial successes in the BTG portfolio, says that the government and BTG have ignored the views of BTG's inventors, whilst consulting with "all sorts of secondary bodies", such as the CVCP. Mansfield would like to see shares in BTG offered to the investors responsible for "the creative work" behind BTG's commercial success.

Peter Aldhous

in Marin County, north of San Francisco, where conditions are so extreme that the water district has imposed a mandatory water use limit of 50 gallons per person per day. The county ran a pilot desalination plant for three months last autumn, using the process of reverse osmosis to remove salt by forcing seawater through fine membranes.

Voters will decide in November whether to build a \$60-\$120 million permanent plant, rather than building pipelines to import river water from a neighbouring region.

A desalination project about ten times larger, designed to generate 100 million gallons of drinking water a day, is under consideration by a team of Southern California utility companies.

A six-month, \$600,000 study started this month to evaluate the feasibility of constructing the plant across the California border in Mexico. Rather than reverse osmosis, the huge project may use the other common desalination technology, distillation, in which the sea water is boiled and the fresh water condensation collected.

There are those in California who are not content with harnessing the sea and the clouds for fresh water, but who are thinking even bigger — on the scale of rearranging the entire North American continent to equalize the fresh-water supplies which are concentrated in Alaska and Canada. Ideas for ambitious projects have been tossed around for decades, but one of the most overwhelming was revived last year by a group now known as Citizens for Water and Power in North America, Inc. (WAPNA).

Led by Robert Finch, a former lieutenant governor of California, WAPNA proposes to dam three rivers in Alaska and Canada's Yukon Territory, and direct water through a vast chain of reservoirs, dams and trenches into the largest water catchment ever attempted — a 500-mile-long reservoir created from a gorge in the Canadian Rockies — before delivering water to 23 states in the United States as well as regions of Canada and Mexico.

The project would take 30 years to build, planners estimate, so clearly would not ease this drought, but it might relieve the next one. Planners say the project, at an estimated cost of \$300,000 million, would deliver 160 million acre-feet of water per year. (California consumes about 34 million acre-feet per year.) It would also yield 70,000 MW of hydroelectric power, of which 30,000 MW, or about 10 per cent of the current American consumption, would go to the United States.

Various proposals for massive relocations of water have been put forward for years, but nothing close to this magnitude has been successful. Mega-projects are inherently difficult to nurture, given the daunting political and financial hurdles they must surmount, not to mention opposition from environmental groups.

Finch, however, hopes that the current drought may provide him with more sympathetic listeners.

Elizabeth Schaefer