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A HUNDRED and one years ago at the Berlin Conference, 12 European countries and Turkey agreed that a nation could claim as its own any of equatorial Africa that it could conquer and develop. The blank map of central Africa was soon treatied into a pastiche of European colonies bordered by rivers, lakes, and convenient straight lines, with little regard for Africa's existing ethnic, political, and ecological patterns.

Germany—to its detriment—chose to conquer part of the Zanzibar Sultanate, now Tanzania. Diseases, pests, wild animals, and local resistance bled German East Africa. At the end of World War I, the colony was lost. Most of it went to the British, becoming virtually an extension of British East Africa on the north—now the nation of Kenya.

This region just south of the Equator is the land of Livingstone and Stanley, Burton and Speke, Isak Dinesen and Denys Finch-Hatton, the Leakeys and possibly the earliest humans. Europeans—not just those ill-fated Germans, but all who came—set out to "conquer" or domesticate it to commercial uses. Legends and lore portrayed East Africa as a primal land. The tribal life and the vast herds of animals verified it. The people were useful, but the herds had to give way.

Kenya game control officer J. A. Hunter noted on one page of his journal that his rhino kills between August 29, 1944, and October 31, 1946, totaled 996. Even when the taming of East Africa enjoyed high priority, pleas to save the animals were heard though not often heeded. To many, the land with its rich wildlife seemed inexhaustible.

In the century since the Berlin Conference we've learned it's not. In 1940 the famous Serengeti National Park was set aside in Tanzania to save a sampling of its wildlife. But the continuing struggle for food and prosperity in a desperately poor land has been a tightening noose around the preserve.

Has it stopped the loss of wildlife? No. Can it preserve a sampling? You'll find answers in our lead story—a blunt report on the state of this spectacular zoo in the wild.

Wilbur E. Garrett

EDITOR

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COVER: *A lioness and her cub bask in the protection of the Serengeti, Africa's premier wildlife haven. Photo by Mitsuaki Iwago.*

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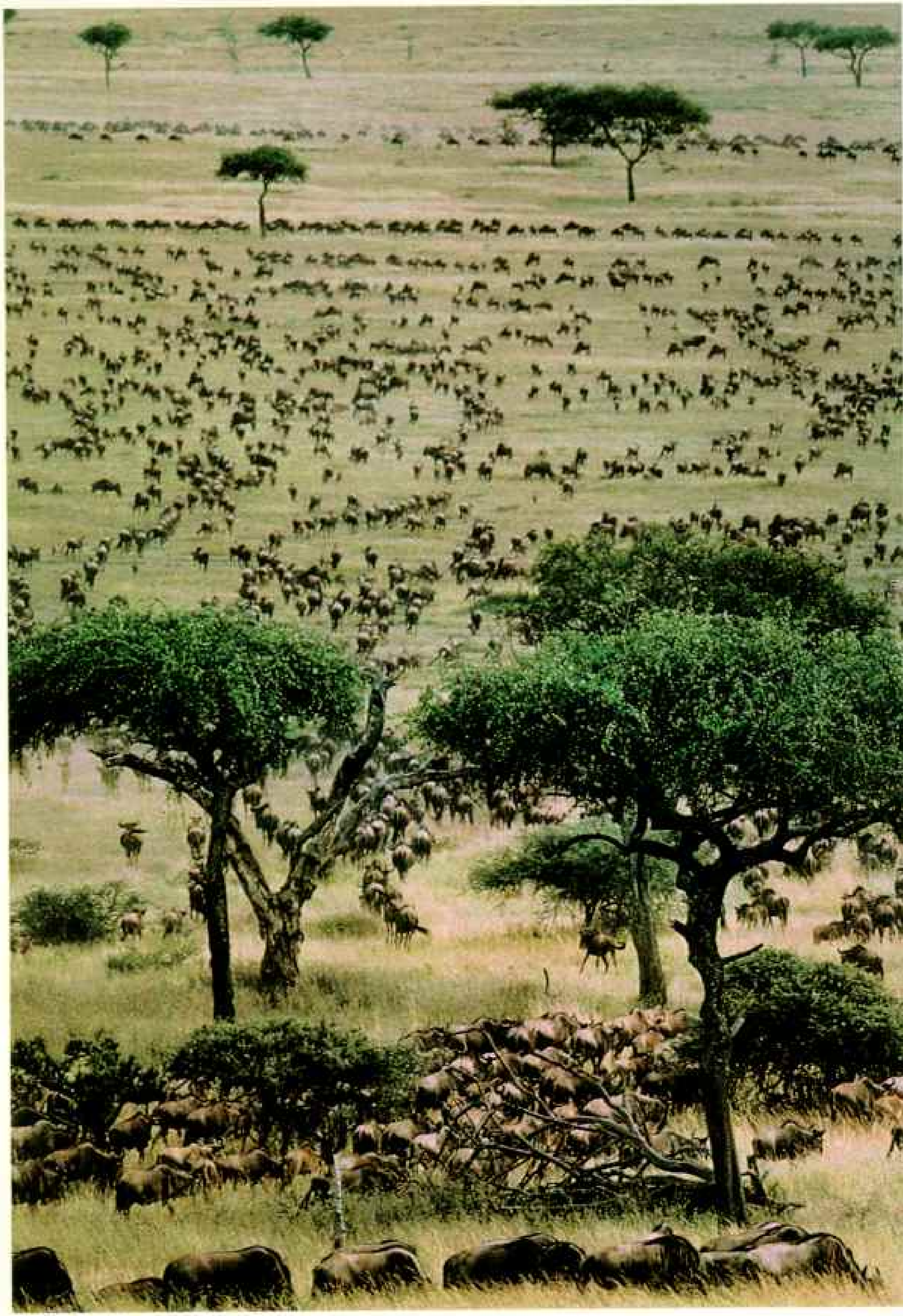
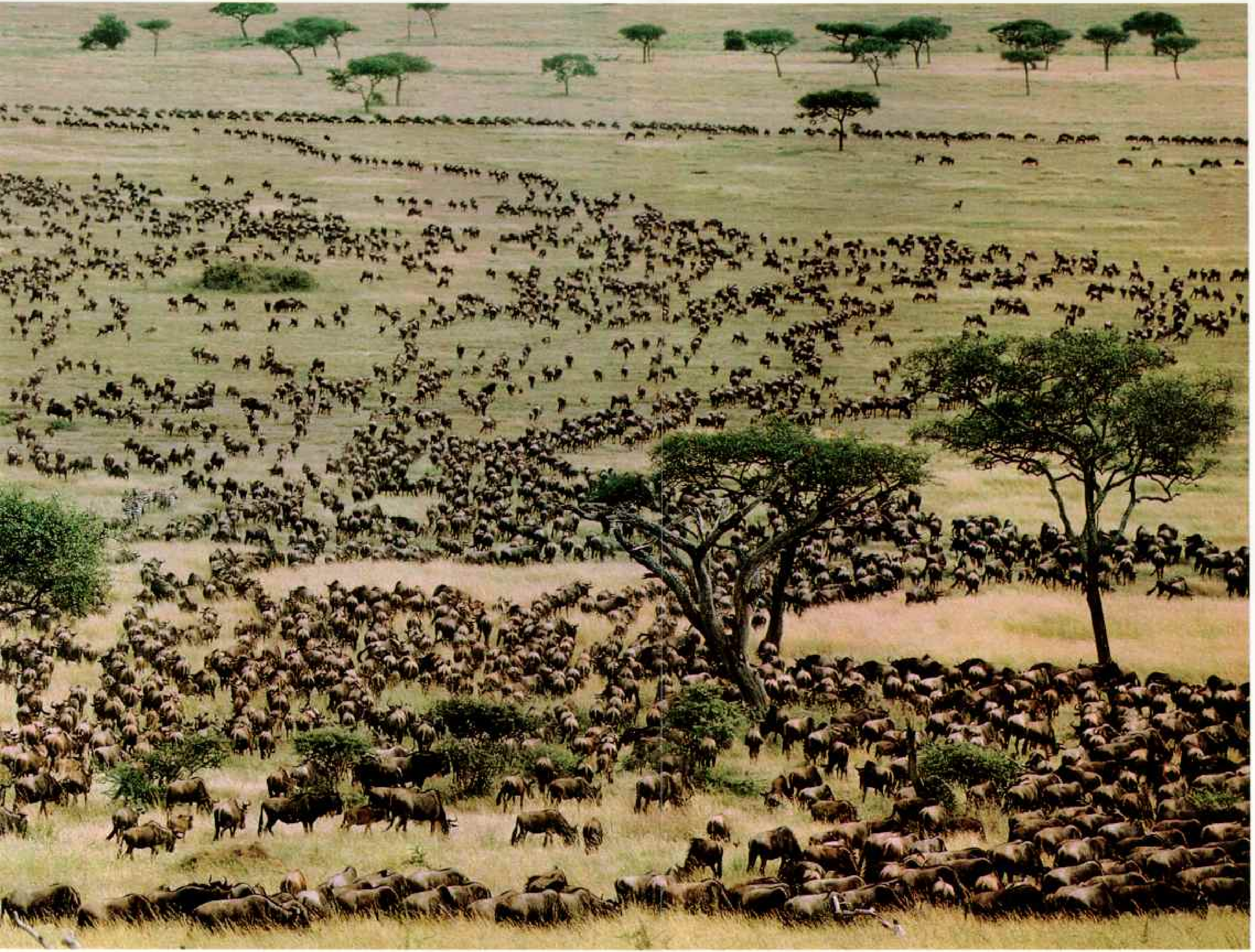




The Serengeti

A Portfolio

By MITSUAKI IWAGO

It has been called the quintessence of Africa, a realm where childhood dreams, instilled by magical picture books of animals, spring to life. It can be gripping and intense, a place of the quick and the dead, as when a cheetah's blinding speed dooms a Thomson's gazelle (following pages). Or it can simply take one's breath away, in May, when clouds of migrating wildebeests sweep the horizon (foldout, left). To record such spectacles, Japanese photographer Mitsuaki Iwago and his family lived among the animals for 18 months.

More than two million large animals roam the savannas and woodlands of Tanzania's Serengeti National Park, with many more nearby. And with many more dangers nearby, dangers not from predators of the wild but from predators of our own kind—poachers who harvest ivory and rhino horn for man's superstitious use, and farmers hungry for subsistence. Will this African wildlife pageant pass away, as in a dream, or will it somehow survive our rapacious century? Shana Alexander's story begins on page 585.

Regal nonchalance comes naturally to young lions lounging on a parched lake bed during the dry season in Ngorongoro Crater. A 100-square-mile bowl teeming with wildlife—and tourists—this ancient volcanic caldera encompasses a separate ecosystem adjacent to the Serengeti's. Fed by rains, a lake in the crater blooms with migratory flamingos (right), mouthfuls that may tempt lions but more often are snatched by hyenas.

Where water lingers during drought, so does food—an elemental fact of life for two lionesses with hungry cubs. One female hangs from a wildebeest's nose to drag it down while the other claws from the rear (right); a neck bite then strangled the prey. Concealed behind the bank of a small stream, they jumped their thirsty quarry from ten yards. The wet season brings flies to torment another lioness (below) dozing on an outcrop called a kopje, claimed by prides for shade, visibility, and shelter from their main natural enemies—other lions.

Impalas explode into high jumps, behavior that can reflect fear or other kinds of excitement. Highly possessive males attempt to recruit a rival's females and young, competition that sometimes triggers such nervous leaps and bounds.

Another group huddles during a sudden shower (left). Impalas remain year-round in the Serengeti woodlands and are prey for leopards and lions able to hunt migratory species such as wildebeests, zebras, and gazelles only part-time.

Shimmering abstractions, zebras may seek safety by joining a

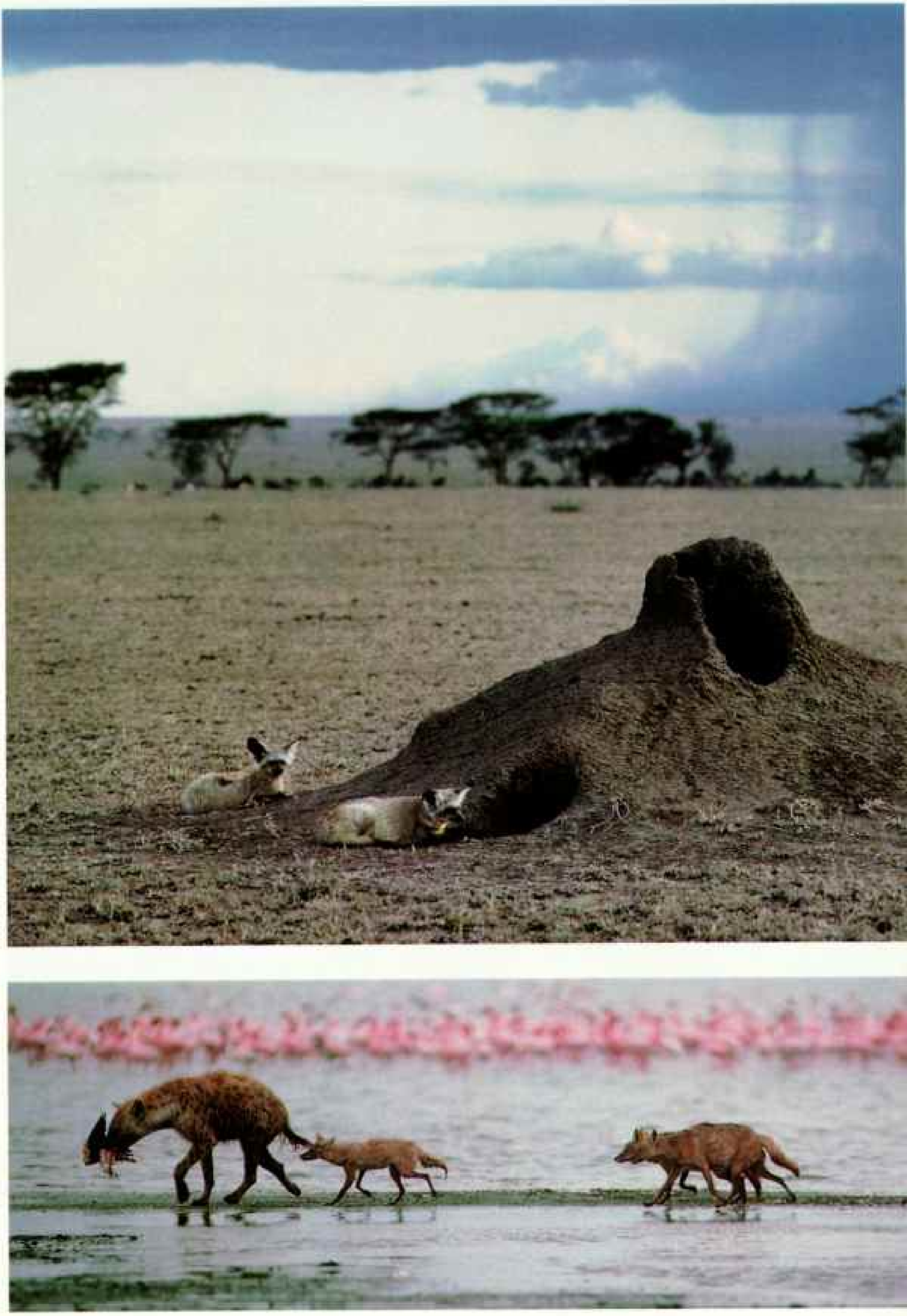
river of wildebeests migrating across the plains in spring.

Like surgical knives, wild dogs close in on a 360-pound meal of prime wildebeest (left). For five days Iwago had followed this pack of 22 dogs, nearly the plains' entire population, probably decimated by distemper and hyena competition. As the large male made a stand, Iwago inched closer—and in desperation, the wounded animal backed into his vehicle to protect its rear (below). Later it was quickly dispatched by the dogs, predators successful in seven of every ten hunts.

Horned avalanche, some of the park's 1.5 million wildebeests migrate

across a river. Hundreds drown in such pileups, especially calves.

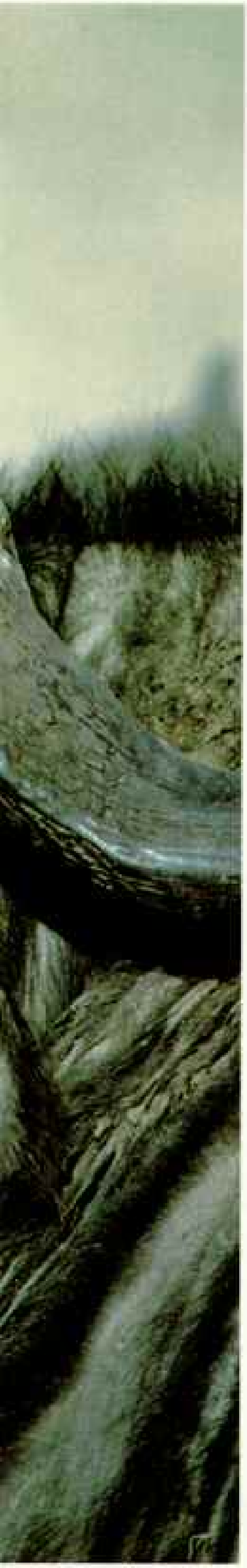
In a war of the lions, two males joined forces to kill a third. Iwago was watching a male and female, probably a breeding pair, when another male appeared and challenged. As the two males squared off, a third male arrived. Tail raised, he grappled with the challenger (above), later also attacked by the female's mate. The third male bit the skull of his foe, near death (right). The victors likely were members of the same pride.



A storm softly curtains a plain where bat-eared foxes raise their young in a termite mound (top left). A few cubs fall prey to golden jackals, such as these hoping for leftovers from a spotted hyena's flamingo dinner (left). Olive baboons feed on the ground (top) but may rest and sleep on kopjes, where hyraxes (above)—believed related to elephants—cluster for warmth.

Opening wide, three tons of rage lets fly at a rival male hippopotamus (right) for dominance in a lake. Its mouth more profitably agape, a saddle-billed stork nips up a small fish (below). Rather than images of tooth and claw, the memory of Serengeti that endures for Iwago is a gentler one: "The wind. Always the wind, rolling across the plains. Sometimes nice, sometimes not. But always there."

TEXT BY JOHN L. ELIOT SENIOR EDITORIAL STAFF



THE SERENGETI

The Glory of Life

By SHANA ALEXANDER

IN INKY DARKNESS, hyenas barked and laughed on the Serengeti Plain. Then the sun seeped over the horizon, turning the morning from lavender to pink to the flame blue of African daylight. Now thousands of moving beasts shimmered at the rim of the sky like a heat mirage—the multitude of wildebeests flowing westward at the end of the rainy season.

In a single sweep of the eye, one could see 5,000 living creatures. At my feet a family of spur fowl—red-masked, huge-footed—scurried across the track. Fat elephant dung, still steaming, lay on a papyrus-edged dam. In distant, pied tree shadow, giraffes fed.

Gazelles abounded. Serengeti has a quarter of a million of the most numerous species, Thomson's gazelle—the beloved little "Tommy" with ever flagging black tail—and many thousands of the larger Grant's gazelle, lilac fawn color with white backside. Kopjes, huge tree-tufted piles of boulders, rose like islands in the sea of grass. The nearest was overrun with rock hyraxes and bright orange-and-blue lizards. A pair of dik-dik antelopes, the size of tomcats, browsed nearby. Two female lions lay belly up on the flat topmost stone. One idly lifted her hind leg, revealing a third and fourth lioness. They were all looking in the same direction, and looking too, I saw him—a big male lion with black-tipped mane and tail, a kingly creature of habit on his morning stroll, cleaving the tawny savanna.

In a meadow of purple wildflowers plump zebras grazed among the wildebeests like glass beads on a black necklace. We came up from the rear on a herd of *Loxodonta africana*, 70 elephant rumps in baggy trousers. With trunks upraised, they moved off, trumpeting, the infant elephants barely visible in the great forest of legs. Two incandescent rainbows of birds—blue, green, orchid—whirred out of a bush to devour insects kicked up by the herds. In a

GRIZZLED BUFFALO BULL eyes a yellow-billed oxpecker plucking parasites from its hide. Buffalo numbers are falling, due largely to meat poachers with whom lions must compete, while agricultural settlements of hungry villagers crowd the Serengeti Park's borders.

MITSUAKI IWAGO

yellow fever tree a vervet monkey was stealing eggs. Eight or nine Fischer's lovebirds—small vivid jade parrots—darted into the tree. Beyond them a pair of large topis stood as if carved in wood, each atop its own termite mound to gain a better, slightly elevated view of the lion-haunted landscape. Rarely do Serengeti lions have topis for breakfast.

At high noon my binoculars strayed to a stout sausage tree. In a light-dappled fork 15 feet above the wildflowers lay a perfectly camouflaged leopard. Minutes passed before the big cat stretched its muscular neck down the trunk, extended a thick foreleg and paw, and slithered away like a great snake into the grass, raising a cloud of white-and-yellow butterflies.

In late afternoon two big, steely gray rainstorms moved in fast from the east. Seventy white-backed vultures and a pair of hideous pink-necked marabou storks roosted in a dead tree or huddled by the putrid puddle beneath. One hunched a scraggly neck down into lousy shoulders and turned his back, as if ashamed to face us with his filthy habits.

The rainstorms merged and produced a double rainbow, one inside the other. Seven lionesses and three young males rested together in the soft rain, beneath an iridescent halo of pearl pink and surrounded horizon-to-horizon by dark blue sky.

MY THOUGHTS TURNED to the cave paintings of Cro-Magnon man and his powerful dream sense of being surrounded by streams of running game. Here in Tanzania's Serengeti National Park the dream still lives. This vast wilderness of semiarid grassland and woodland, lying just south of the Equator, is the greatest natural wildlife spectacle on earth. Yet its preservation has resulted in an unnatural isolation from the rest of the continent. Today the only humans permitted inside the preserve are paying tourists, the Africans who work in and police the park, and a few resident scientists.

Roughly the size of Connecticut, the 5,700-square-mile park is part of the Serengeti-Mara ecosystem. The ecosystem is about twice the size of the park and is defined by the annual wildebeest migration. The triangular migration route extends from Kenya's Masai Mara reserve and the Serengeti woodlands of Tanzania in the north, southward to the Serengeti Plain as far as the spectacular volcanic highlands of the Ngorongoro Conservation Area, then westward to Lake Victoria.

Around the park perimeter to north and east dwell the nomadic Masai herdsmen with their cattle. They and other peoples who live and farm and hunt to the south and west coexist in an ecosystem so in balance that one can arrive on a scrubby, dry plain only weeks after a million animals have passed by in annual migration and find the hard ground absolutely free of droppings.

I was introduced to the Serengeti by Dr. Markus Borner, the Frankfurt Zoological Society's representative in the park. Borner, a compact, ruddy Swiss who wears a khaki flight suit and one gold earring, flew me down from Nairobi, over Kenya's Lake Magadi, covered with a crust of alkali, past Mount Lengai, the Masai's holy volcano. From the air I saw mud villages and the cattle of the Masai but little sign of agriculture and few roads.

It was a memorable flight—Markus prefers altitudes below 350 feet so that he can observe and count the animals in their unimaginable numbers and variety flowing beneath the wings of his Cessna. Animal census is Markus Borner's specialty. Now, as I sipped wine with him and his wife, Dr. Monica Borner, on the porch of their bungalow in the park, conversation turned inevitably to *Serengeti Shall Not*

Author **Shana Alexander**'s most recent book, *Nutcracker*, studied a case of parricide in Utah. Her next, *Dangerous Games*, studies lawyers in action. Wild animals are a peaceable contrast, she says. Award-winning Japanese photographer **Mitsuaki Iwago** has conducted wildlife projects that have taken him to the far corners of the world including the Arctic and Antarctic. They have resulted in the publication of three books.

ALAN ROOT

KNOWLEDGE ON THE HOOF: Airborne researcher tracks radio-collared wildebeests to study their range and patterns of movement. The Serengeti's gentle, usually accessible terrain attracts a host of scientists; as many as a dozen projects may be underway at the Serengeti Wildlife Research Centre, established in 1962.

Die, a book by Dr. Bernhard Grzimek of the Frankfurt Zoological Society published in 1959. Activists have been discovering trouble in paradise ever since; many have prophesied the end of the Serengeti world. Markus Borner, as an expert on the park's animal populations, is more optimistic.

"I'M SO TIRED of hearing that!" Borner burst out. "Basically, the Serengeti is thriving. Most animal populations in fact are stable or increasing." The wildebeest herd has increased from 250,000 in 1960 to 1.5 million in 1978, and remains stable. Zebras remained stable at 200,000 from 1960 to 1980, probably kept so by the lions and other predators. African buffalo increased steadily through the early 1970s, though in the past decade there has been a marked decrease. Borner suspects the decline is due to meat poaching and a combination of drought and rinderpest. A great rinderpest epizootic decimated the wildebeests and nearly wiped out the Masai cattle in the early 1890s; immunization programs now aim to create a rinderpest-free zone around the Serengeti. Lions take cover in the brush and cannot be accurately counted from the air, but they are rapid, successful breeders, and specialists believe that they too are increasing and may number around 3,000. The giraffe population seems relatively stable.

The elephants, recently returned, are in danger. Thirty years ago the Serengeti had no elephants. Today it has perhaps 2,000, forced out of areas north and south of the park by increasing human activity. Recent poaching has been so severe in the

northern Serengeti that the elephants have redistributed themselves, some moving south to mid-Serengeti, others up into the Mara. Elephants have been hunted for their ivory for centuries, and at last the old bull with great tusks is vanishing. Ivory poachers had slaughtered four elephants in the northern Serengeti the week before I arrived. In 1981, wardens found eight elephants slain for their tusks. They discovered 23 in 1982, three in 1983, and 64 in 1984. Authorities say many more were killed but not found. Today all appear spooked, every naturalist I talked to agreed. The elephants seem to know that they are being hunted.

THE ANIMAL that is most endangered by poaching is the rhinoceros. In the early 1970s the park contained about 500 black rhinos. Today fewer than 20 survive. The animal is slaughtered for its horn, which is not a true horn but hard-packed hair and other fibrous keratin. In Asia powdered rhino horn is widely believed to possess medicinal value, and it is used as an aphrodisiac in parts of India. But the main market for the horn is North Yemen, where it is made into ornate, highly polished handles for the *jambiyya*, a curved dagger worn as a badge of manhood and class. Rhinos have a 16-month gestation period, a two-year lactation, and only a 30- or 35-year life span. The rhinos are on the brink of extinction, even though new young ones are being seen.*

Impalas decreased in the northern Serengeti when fire and elephant damage destroyed much of the woodlands. But elsewhere they have flourished. Topis have also increased. The wild dog population may be on the rise after a recent decline, perhaps due to canine distemper coupled with a rise in the number of hyenas, intense competitors for food, especially during the dry season. "The Serengeti is a very complex ecosystem," says Borner. "We don't want to interfere—but we must hold down the poaching so that we can observe how nature really works."

But in a continent haunted by famine, it is difficult in some cases to view illicit harvesting as criminal. "It would not be correct to call killing an antelope or zebra or wildebeest to feed one's family meat poaching," says Borner. "Certainly it would be wrong to outlaw killing all wild animals for food—with millions of wildebeests, a few thousand animals is no big loss."

Although hunting is prohibited within the park, thousands of animals are killed every year by human beings. Most poachers are Wakuria tribesmen from the northern and western borderlands of the Serengeti. Almost all of those arrested are armed with bows and poison arrows and wire snares. These tribesmen once killed only for their own sustenance. But now a profitable commercial market has developed, and with it a new breed of modern, professional hunter has appeared, sometimes equipped with trucks to carry away his butchered carcasses.

An advance party sets pit traps for migrating wildebeests, and a follow-up gang herds the animals into them. All the poachers need is a hundred-yard-square patch of bush, far from the few roads and invisible from the air, in which to butcher and dry the meat. While the hunters and butchers continue to follow the moving animals, runners, moving in darkness and dodging from one staging post to another, carry the dried meat out of the park.

A further toll is exacted by the trophy poachers, using two-way radios and automatic weapons to slaughter elephants and rhinos, hacking away the prized tusks and horn, leaving the flesh to predators and putrefaction.

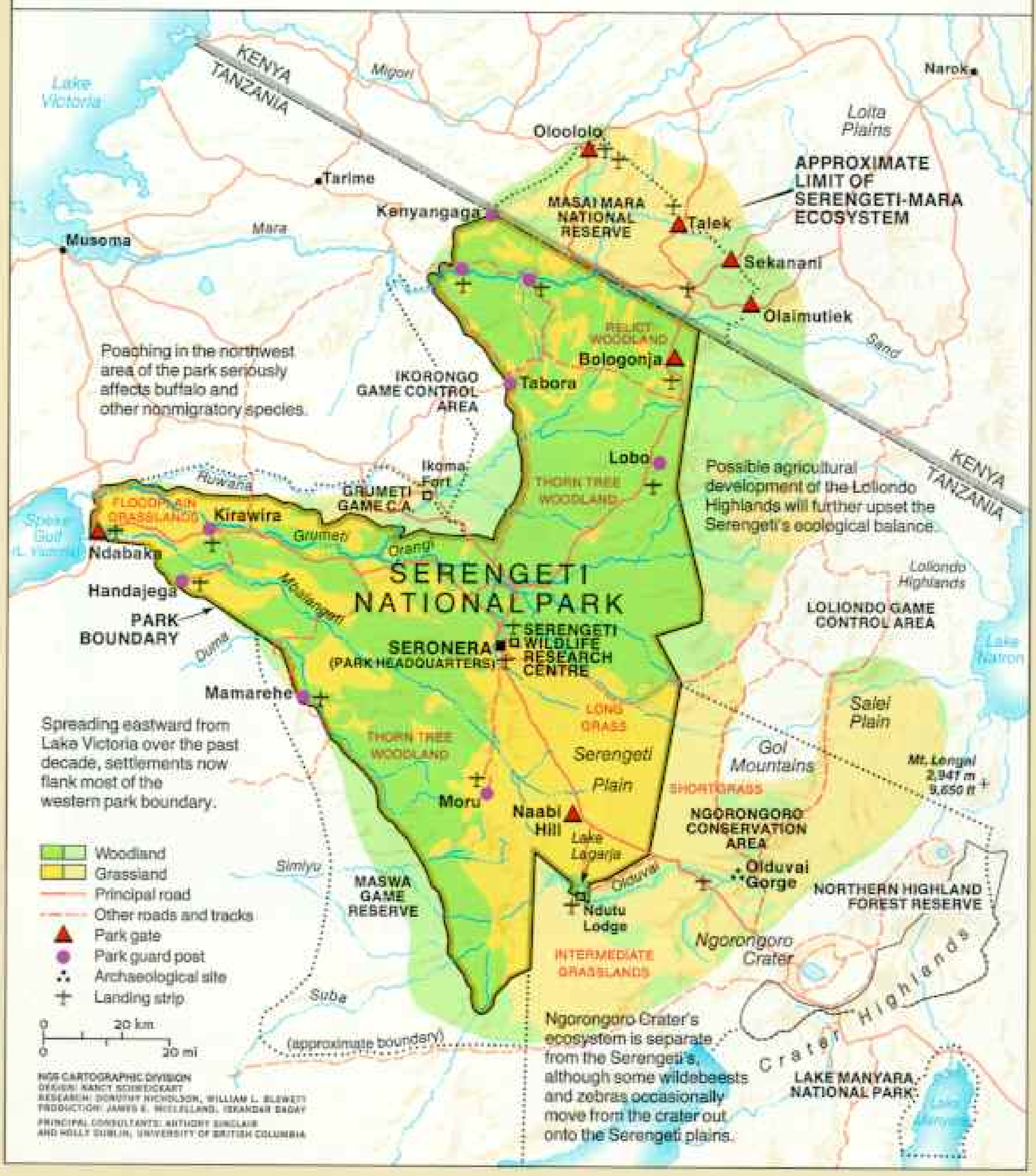
In 1978 Tanzania established a national antipoaching unit designed to be on call to all park rangers, but it has been unable to stop the slaughter. Tanzania cannot really afford to maintain its vast park system. In recent years the money budgeted for the Serengeti did not arrive in timely fashion, so that personnel went unpaid and property and equipment fell into disrepair. Although a fourth of the

*See Esmond Martin's article in the March 1984 NATIONAL GEOGRAPHIC for more on the plight of Africa's rhinos; for elephants, Oria and Iain Douglas-Hamilton's November 1980 piece.

The Serengeti

IMAGINE Vermont as a vast tree-fringed meadow reverberating with the thunder of millions of hooves and the snarls of their pursuers, and the scale of the Serengeti ecosystem becomes apparent. The park was created in 1940 and now protects about half the area. Because of conflicts with the Masai and their cattle, the Crater Highlands and eastern plains were partitioned from the park in 1959, and a large northern area was added to it. In 1974 Ngorongoro Crater gained separate protection, and the Masai removed. They may still water their herds within but must leave by nightfall.

The Serengeti's pulse beats to the migration cycle. Wildebeests, zebras, and gazelles graze the southeastern plains during the wet season, from December until May. Then they move west into the woodlands, later spreading north into the Mara. With the end of the dry season in November, they return to the plains.



NGS CARTOGRAPHIC DIVISION
DESIGN: NANCY SCHIEDEKART
RESEARCH: DOROTHY NICHOLSON, WILLIAM L. BLEWETT
PRODUCTION: JAMES E. MCCLELLAND, ISKANDAR BADAY
PRINCIPAL CONSULTANTS: ANTHONY SINCLAIR AND HOLLY DUBLIN, UNIVERSITY OF BRITISH COLUMBIA

JOHN ROSS

ANYTHING IS FAIR GAME to poachers who string lethal and indiscriminate wire snares between trees. Prized for charms such as its claws, this lion had broken free of a trap but was still entangled by wire. Dr. Craig Packer tranquilized it to cut away the impediment. For eight years he and Dr. Anne Pusey, his wife, have studied Serengeti lions, with partial support from National Geographic Society research grants.

country is contained within parks and reserves that enjoy some sort of protection, and Tanzania spends one and a half times as much of its national budget on conservation as does the United States, the total (two million dollars) is tiny compared to the magnitude of the job to be done, and I heard many pleas for donations of funds and equipment from the outside world. The largest outside contribution currently comes from the Frankfurt Zoological Society—about $450,000 a year. The World Wildlife Fund, African Wildlife Foundation, and New York Zoological Society also have been longtime supporters.

Serengeti's chief warden commands 75 rangers distributed among nine outposts. They maintain continual patrols through the bush and over 150 miles of track. In theory each outpost has a four-wheel-drive vehicle and an airstrip, as well as "some tents, but not enough," arms and ammunition, and a working shortwave radio, thanks to solar-battery chargers donated by Frankfurt. But the park's one small airplane is not always airworthy, and fuel is always in short supply. The vehicles, shuttling continually between posts, have a short life expectancy.

Despite these handicaps, Serengeti rangers operate with remarkable efficiency. The number of poaching convictions increased from 108 in 1957 to 415 in 1984. A new chief warden, Bernard Maregesi, who was appointed after my visit, is said to have introduced morale-boosting policies, and some new vehicles have been delivered. But difficulties and dangers persist.

CRAIG PICKER

SMALL DENT in the poaching traffic, tribesmen arrested in a meat-laden camp within the park are guarded by a ranger; poison arrows may finish off snared game. Tanzania's anti-poaching campaign lacks funds to fix and replace patrol vehicles.

A ranger post had been attacked with automatic weapons only days before I arrived. Military weapons and ammunition are readily available on the black market in this part of the world to anyone who can pay for them. A ranger earns about $75 a month—sometimes risking his life for a wage that may be weeks late in coming.

Finn Allan, my companion, the son of a former warden of Serengeti National Park, has known the park since his youth and is acquainted with its splendors and problems. Among the problems is the rivalry between capitalist Kenya, where Finn was born 38 years ago of Scandinavian parents, and socialist Tanzania.

In 1977, after years of contention over tourist revenue, Tanzania abruptly closed its border with Kenya. Tourist dollars were being spent in Kenya on travel and for safaris led by entrepreneurs who trekked foreign visitors down from Nairobi to view Tanzania's wildlife but did not leave many dollars behind. But closing the border only made matters worse because revenues from tourism dried up almost completely. When the border was reopened in 1983, many tourists still arrived through Kenya, and Tanzania began charging those who do so higher entrance fees—currently $75 a day per vehicle and $15 a day per person, plus camping and other fees.

*"SUPERPREDATOR in his larder," wrote Dr. George Schaller, pioneer Serengeti lion researcher, of a poacher whose arrest he witnessed (**right**). Racks of dried meat cover the camp, which also contained 51 fresh kills of 12 species. Hunger fuels the market for illegal meat, clandestinely sold.*

*Tons of meat lie rotting on the plains—elephants stripped of their ivory, trunks hacked off (**below**). Efficient waste is the trademark of highly mobile poachers with automatic rifles—a proliferating species.*

GEORGE B. SCHALLER (ABOVE); THOMAS R. SMITH, NATIONAL GEOGRAPHIC STAFF

By the time the border was reopened, however, the park lodges and staffs, as well as roads and equipment on which tourism depends, had all deteriorated. The prize Seronera Lodge, where I first stayed, is an impressive pile of timbers and stone built onto and incorporating a huge kopje. My cedar-and-glass room smelled musty. A man staggered in with a ten-gallon gasoline can of water to fill my toilet tank and pour an inch or two of cold water into the sink and tub. Night was falling. I inserted the light bulb I'd been advised to bring and drew the curtains. An exotic mortuary of grasshoppers, locusts, moths fell out of the rotting fabric.

IN CONTRAST to the lodges, scientific inquiry into the Serengeti has not deteriorated. The Serengeti Wildlife Research Centre was established in 1962 by John Owen, head of Tanzania's national parks. A few years later the famed lion man, Dr. George B. Schaller, was brought in "to examine lion-prey relationships." Studies currently in progress include hyrax behavior and mongoose social organization as well as work on grassland ecology. Markus Borner coordinates his animal census work here.

The Serengeti's great acacia woodlands began disappearing in the early 1960s, when elephants were driven into the park and destroyed large trees. Subsequent fires also consumed large trees along with seedlings and saplings, creating a grassy plain where a forest had been before. Then wildebeests came through and ate the new grass. This reduced the fire hazard, and the trees began to grow back. Now

there are many small borderline trees, but measurement of tree age is imprecise because older acacias are kept short by browsing giraffes.

Like royalty in another epoch, elephants are endearing even when they lay waste the land. If you were Noah, I thought, the first pair of animals you'd push overboard would be the elephants. They eat too much, excrete too much, destroy too much, take up too much space, and are generally hard to manage, especially in confined quarters. But then you would have to imagine a world without elephants.

LION RESEARCH is now headed by Dr. Craig Packer and Dr. Anne Pusey, a husband-and-wife team from the University of Minnesota. They and their colleagues, one American and two Tanzanian graduate students, have put radio collars on 15 female lions. The females catch most of the prey, and the collars enable the team to discover how lions survive when prey is scarce. The resident males defend the females from marauding males. When such marauders succeed in driving out the previous males, they also kill the smaller cubs and drive off the older ones. This behavior ensures that new cubs in the pride will be the progeny of the stronger reigning males, since it also causes the females to come into heat.

Clare FitzGibbon, 22, a shy doctoral candidate from Cambridge University, studies gazelles and their predators, including the cheetah. She looks not unlike the cheetah—blond, slender, and finely made. Some cheetah males have territories, while others float, and she was studying the benefits of floating. The population ratio is three female cheetahs to two males. There are about 300 cheetahs on the plains, which constitute some 20 percent of the park.

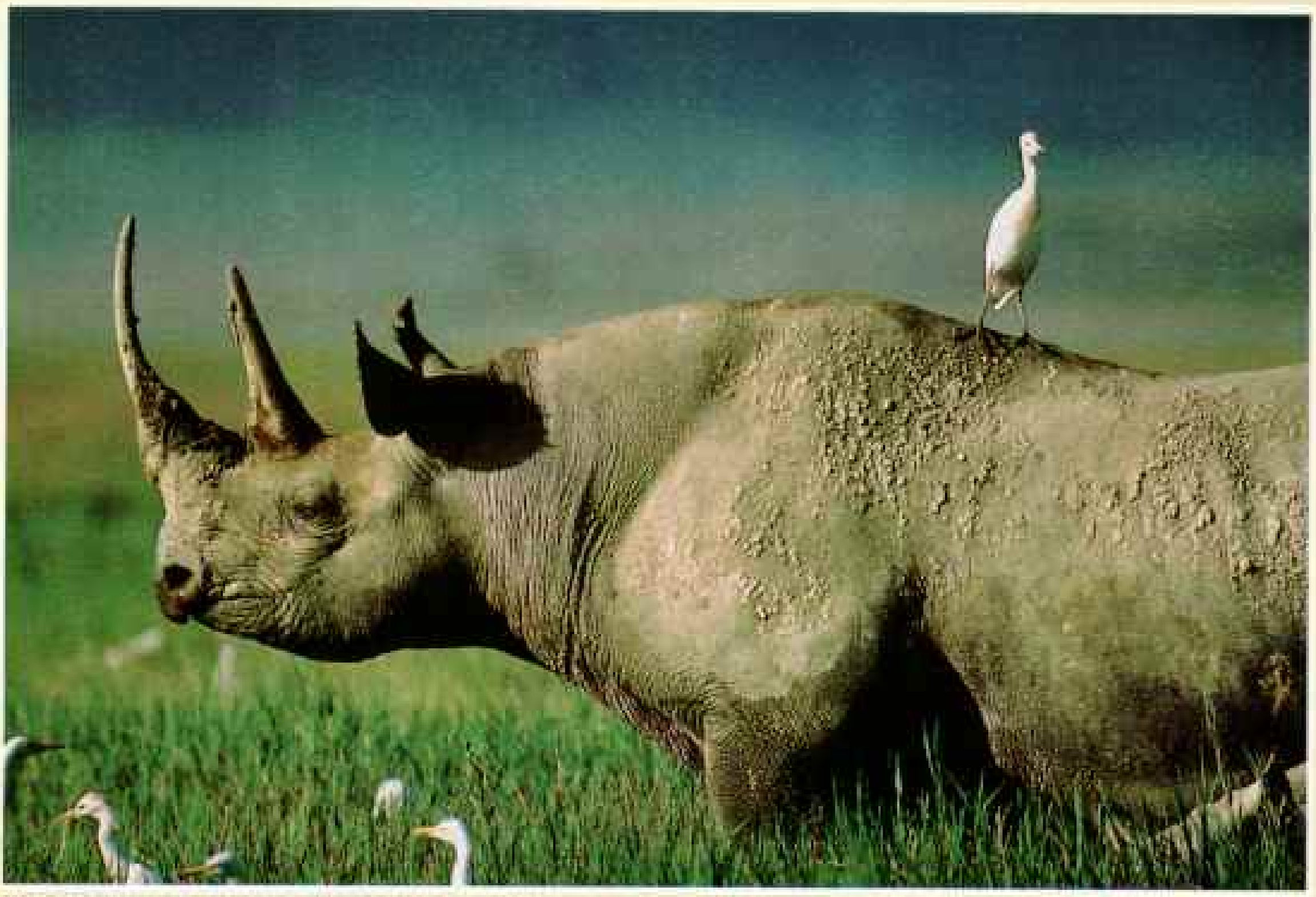
Researchers such as Clare go into the bush alone and live in their vehicles. She spends a week at a time sitting behind the wheel of her long-wheel-base, 16-year-old Land-Rover hoping to see the cheetah, an animal that mostly sleeps. Clare usually waits two days to catch any action. Sometimes *she* falls asleep and misses it. Then she must watch for another two days. "A lot of waiting," she said, then smiled. For protection Clare is armed—only—with two fire extinguishers. She comes home to Seronera once a week, to bathe, and had recently discovered that a leopard uses her roof to catch hyraxes.

The presence of all these scientists and increasing numbers of tourists inevitably changes the behavior of the animals they are here to see. George Schaller reported that two out of three attempted lion kills do not succeed. Could it be that the presence of so many animal watchers, despite the scientists' best precautions, has something to do with this inefficiency factor?

ON OUR WAY to Ngorongoro Conservation Area in Finn's Range Rover, we continued across the Serengeti, about 5,000 feet above sea level. Beyond Olduvai Gorge, in the far distance, the cloud-wisped Crater Highlands rose to 11,000 feet. In a muddy culvert 22 ragged ears, 11 hyenas, raised their ugly heads. One female, very pregnant, muddy belly hanging, got up and wallowed away from our car. "Probably newborn cubs in the culvert," Finn said. Four more heads popped up, bearlike faces spotted and muddy, like hideous teddy bears.

We watched seven young lions feed on a young wildebeest, their early morning kill. One lifted a red-dripping muzzle to stare at us before returning to the meal. Two other cats, already gorged, lay panting in the heat. "They will eat all but the tail and some skin and bones," said Finn. No sound but lion gurgle, and a strong smell. Overhead, a black-and-white Egyptian vulture circled patiently, watching, waiting. Out beyond the lions, jackals waited to scavenge the lions' leavings.

In the distance a lone young wildebeest, running fast, made a mad dash to rejoin the herd that grazed more than two miles away. The wildebeest—actually a species of antelope—is a ridiculous-looking animal with a horned, block-like head, long white beard, and a fondness for stampeding and bucking like crazy. This one

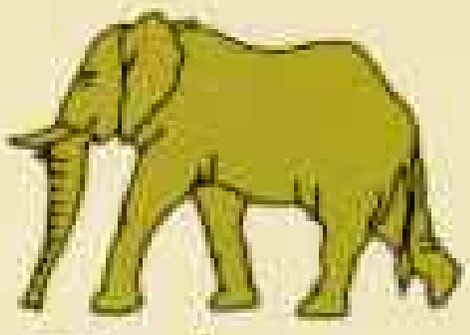


CATTLE EGRETS SEEK INSECTS STIRRED UP BY A BLACK RHINOCEROS

MITSUAKI IWAGO

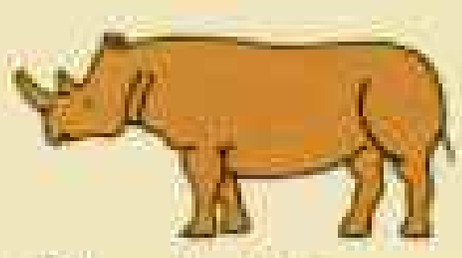
Poachers' toll

The most endangered species in the Serengeti, the heavily poached black rhinoceros has been severely reduced; elephant slaughter has also risen alarmingly. Body counts portray only part of the bad news—they do not reflect undiscovered carcasses.



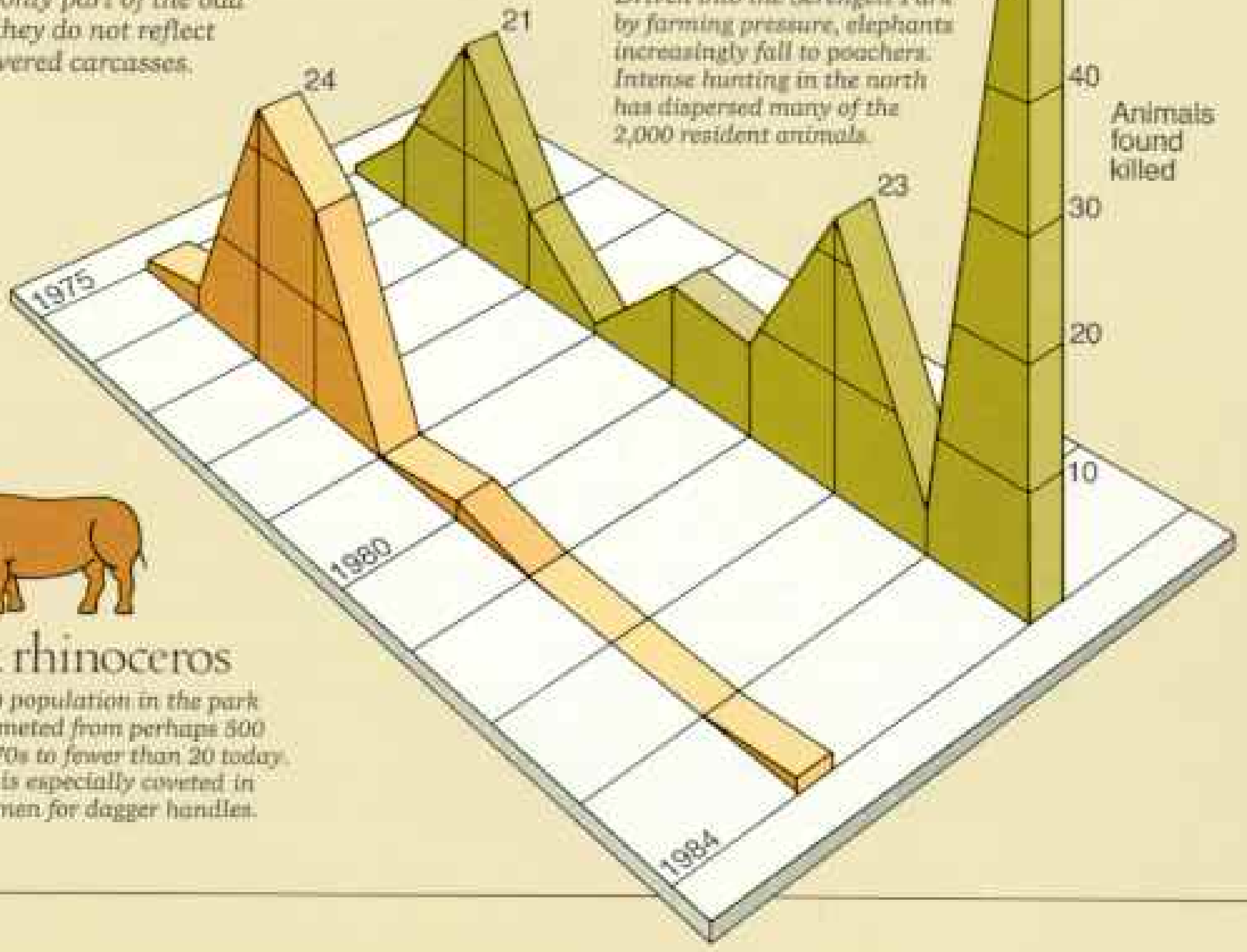
Elephants

Driven into the Serengeti Park by farming pressure, elephants increasingly fall to poachers. Intense hunting in the north has dispersed many of the 2,000 resident animals.



Black rhinoceros

The rhino population in the park has plummeted from perhaps 500 in the 1970s to fewer than 20 today. The horn is especially coveted in North Yemen for dagger handles.



MITSUAKI IWAGO

TALL ORDER of acacia leaves is taken by a giraffe. Full-grown acacias dwindle, partly because these browsers prefer young trees, inhibiting their maturity.

would need to find a way to get past several gangs of lions. Dodging, angling wildly like a broken-field runner among the dry scrub, the calf got through the danger zone where seven lions watched from a tussock, then crossed the range of a second lion trio, and, near exhaustion, finally plunged across his goal line back into the herd. But the herd was over a thousand strong. It seemed unlikely he would find his mother. Another predater, another day, would almost certainly eat him.

The wildebeest is the plankton of this sea of grass. Its great annual migration across the Serengeti, insofar as the constant movement of a million and a half grazing animals can be said to have a beginning and an end, commences in the spring in the breeding grounds of the shortgrass region of the southeast. The herd moves west toward Lake Victoria across long-grass savanna, a hundred miles wide, to the woodlands, turns north to the Mara, and finally returns to the shortgrass. The whole journey amounts to a great circle of some 500 miles, with all the predators and scavengers of the plain following alongside.

In late May the rutting season was just beginning. In January or February, during the "long rains," the three-week calving season would occur. Nature has arranged it so that all the animals calve in the morning at approximately the same time and in the safest possible place—there is very little cover around here. Within minutes the newborn calf is able to follow its mother and move with the herd. Each calf imprints at birth on its own mother and must remain attached; otherwise it becomes almost certain meat for the waiting predators.

Due east of the ranger post at Naabi Hill, two miles out on a parched plain devoid even of scrub growth, we spotted Clare's ancient Land-Rover. She was reading Balzac by sunlight while monitoring an underground den of African wild dogs. In the shade of the tailgate lay one sullen dog, yellow-eyed, mud-colored, thick-footed, head on its forepaws—an eerie embodiment of the hound of hell. At length the rest of the pack came out, four adults and eight or nine pups, mud brown, yellow, and dirty white, each with a black muzzle and eye mask. But the most amazing creature on this entire plain was surely Clare.

Several hours later, climbing now toward the Crater Highlands, we saw our first humans since leaving Clare: two stork-legged, elegant Masai herdsmen, red-cloaked, necklaced and earringed in bright-colored beads, each carrying an iron spear as tall as himself. Bells signaled herds of Masai cattle driven by boys. Smiling, shaven-headed women in bright clothes and beads climbed the mountain alongside our car. The smell of crushed herbs underfoot was almost overpowering.

The Masai live in huts of cow dung thickened with straw and plastered onto a framework of branches, clustered in a fenced compound called an *engang*. They move from one place to the next, seeking good grazing. But these wanderings are becoming more compressed as population increases (there are more than 300,000 Masai today as compared to 115,000 in 1958), due mostly to modern medicine for

JOAN ROOT

BELOVED BUT EXASPERATING BULLDOZERS, elephants have a yen for acacias that also destroys the trees, foreground, helping to convert Serengeti woodlands to grassland. Elephants were virtually nonexistent in the park until the 1960s, when they began to immigrate from the north and south, driven by agricultural pressure.

man and beast. Since Masai herds are growing and pastureland is increasingly limited, much overgrazing occurs.

To the Masai, cattle stealing is an ancient and honorable way of life, but not to pursuers, who sometimes set fires to mark their trail. These "hot fires" are more destructive to tree seedlings and saplings than the controlled fires set by park wardens in a careful, checkerboard pattern timed at the start of the dry season. It is windy in the dry season, and hot fires can travel 15 feet a second. Grass fires are valued by the Masai because they burn away the ticks that cause east coast fever and other bovine diseases. "It's a problem between two cultures," observed Markus Borner.

TO AVOID the trampled and barren areas around waterholes, Masai villages are nowhere near water. The women walk miles to get it—and use very little. Whenever possible they substitute urine. After a brief period of flirtation and fun with the warrior age-set above them, Masai girls endure circumcision, marry, and commence a life of water carrying, wood carrying, and house building. One wonders why the women smile.

Only in a theater operated by a crazed lighting designer or, of course, in a painting

by J.M.W. Turner could one ever have seen so outrageously gorgeous a dawn as greeted us the next morning at Ngorongoro Lodge on the crater's rim. We stopped by ranger headquarters to pick up Martin Men'goriki, 42, the gentle, knowledgeable, powerfully made conservation officer who would be our escort.

When the Serengeti and the Ngorongoro Crater were gazetted—officially made part of the national park system—Masai lived throughout the area, and a conflict developed between their demands for grazing lands and the needs of wildlife. In 1957 a parliamentary commission was appointed to study the problem, and in 1959 the Ngorongoro Conservation Area was established as a multiple land-use project.

Martin, himself a Masai, told us that the Masai had "wanted to develop themselves, to live in modern houses, not dung huts." But such houses would, of course, spoil the crater, which is a pestilence-free heaven of animals. Were man to dwell among the animals, Eden would be spoiled. And so in 1974 the Tanzanian legislature decided to give the crater separate protection. The result: Masai out. The crater is a place where the Masai may still water their herds at gushing springs and visit the salt licks. But only wild animals may remain overnight.

ALAN ROOT

TAME LAWN MOWER. a wildebeest raised by Dirk Kreulen helps him interpret grassland ecology. He records the amounts of different plant species grazed in a plot of known composition, then analyzes what the animal leaves uneaten.

Emerging onto the crater floor out of the clouds on the rim 2,000 feet above, we came upon silver-mauve meadow grass, rippling in the fresh wind like an immense ground cloth of shimmery China silk. It seemed as if we were traveling through a child's picture book of wild animals. Martin pointed to a male Jackson's widow-bird, a curve-tailed black bird that stamps out its doughnut-shaped courting area in the grass by repeatedly leaping straight up and down, like an avian pogo stick.

A hyena loped across the road in front of us, a bloody wildebeest hind leg clamped in its jaws. Fourteen hippopotamuses basked in a clump, like slimy boulders, with oxpeckers, or tickbirds, perched atop their bulging bodies. Wounds and gashes gleamed in raw, fleshy pink against the hippos' mucous-gray hide.

Martin pointed to three black rhinos, whitened by their soda-lake baths, ghostly remnants of the age of dinosaurs against the deep green forest glades and yellow acacia stems of afternoon. All were young males. Probably 30 rhinos now live in the crater. We emerged at the rim into the dense area known as the Northern Highland Forest Reserve. A lone bull elephant grazed dreamily on narcotic wild hemp.

AT LOBO in the northern part of the park, Finn went off seeking gasoline. He returned with the news, overheard on shortwave radio at the fly-specked ranger post, that fierce fighting had taken place early this morning somewhere to the north. Lobo's park warden, Ernest Kapela, 34, acknowledged that there was frequent gunplay between rangers and poachers. And he

ROLF KUES

HOW WOULD THE PLAINS LOOK without hungry mouths to graze them? The dramatic difference is shown by an exclosure where Feetham Banyikwa, left, and Faith Halter study the growth of uncropped vegetation. In practice, grazing by some species stimulates plant growth, thus benefitting the next to feed.

confirmed that early this morning his men had shot and killed two poachers.

Rangers with binoculars had been watching an area where four elephants had been found dead the week before and spotted a suspicious-looking party of men. Two rangers accompanied by a pair of Tanzanian policemen went to investigate. Creeping up the hillside, they stumbled upon a large herd of elephants, at least 60, and had to retreat to avoid being trampled.

When the rangers and policemen were able to inch upward again, they saw the poachers—20 or 30 men—watching the ranger post across the valley through binoculars. A gun battle broke out, poachers began shooting and running in all directions, and the four-man reconnaissance detail retreated. They returned, after a rugged two-mile climb through dense forest, and found the two dead Wakuria. The others had escaped. Night was coming, and the four, fearing an ambush, covered one corpse with cloth, the other with branches, and returned to the post.

When warden Kapela arrived at the scene of the battle next day, much evidence had disappeared. Hyenas had eaten the dead poachers. Nevertheless Kapela was in good spirits, certain that his raid had foiled the poachers' original plan to drive the

entire elephant herd to an even more remote region near the border, where they were unlikely to be seen, and there slaughter them all.

Some evidence survived—four small tusks stuffed with green grass and bundled in old rags. The tusks, from a female or young bull, weighed not more than eight or ten pounds each. Not fresh, they were probably the fruit of the previous week's kills. In the old days one could still find many big bulls carrying 60 or 70 pounds of ivory in each tusk. "Then it was *worth it!*" a ranger said.

The rangers had captured a well-oiled .404 rifle with a homemade sling of eland hide and a much used, old-model Mannlicher elephant gun. They had also seen and heard automatic weapons fire, possibly from a Soviet AK47 or a Belgian FN.

Left behind at the post were the poachers' remains—their gnawed bones—and their meager and sad belongings: some scraps of bloody cloth, a pound or so of butchered elephant meat, a small skin bag of maize meal, two battered cooking pots, and a worn leather quiver containing four poison arrows for hunting small game.

"I take my hat off to these rangers," said Finn. "Four men against 20 or 30 poachers. They don't get paid anything extra, mind you, for being brave."

ROBERT CAPUTO

FIRE IS A FACT OF LIFE AND DEATH investigated by Neal Stronach, who checks the growth of a young acacia. In this area of controlled "cold burns," set at the start of the dry season when grass is still fairly moist, seedlings are able to survive.

FINN HAD SPOKEN to me earlier about the erosion of a man's morale when his monthly salary is only 75 dollars. The white man, by contrast, appears to have inexhaustible money.

"So, from the African's point of view, we're filthy rich. It must seem lunatic to them: A tourist comes here to take pictures of animals, and the cost of one night's stay equals one month's salary for the African. The cost of one bottle of wine equals half a month's salary. One beer can cost 6 or 7 percent of a man's monthly salary!"

For the joy and purity and planetwide uniqueness of being in this part of Eden-Africa, the visitor overlooks all discomfort, or all but one: the odd glimpse of how Africans live—in mean, fly-infested rooms with a mattress on the floor as the only furniture for the entire family. Here dwell skinny children with fly-rimmed eyes and mothers who work like the one-eyed, waterwheel-driving donkeys of Egypt, round and round, dawn to dusk.

These are the people described in a study of human population pressure on the Serengeti ecosystem. With some 20 million people living on 364,886 square miles, Tanzania has one of the world's lowest population densities, but its population is growing at a rate of 3.3 percent a year.

The study found that the rate of growth has been significantly higher along the edges of the Serengeti. About four million human beings live in the eastern Lake Victoria basin—up from only 1.5 million in 1948. As fertile lands on the shore of Lake Victoria became overpopulated, beginning in the 1930s, people drifted

southward toward the borders of the Serengeti. In some (though not all) places along the western rim of the ecosystem, the rate of growth reached 19 percent, with an average of 50 persons living today on a square kilometer of land. The systematic inoculation of cattle against rinderpest and other killing diseases and the clearing of tsetse-infested brush have contributed to steady growth in the number of cattle and a sharp increase in domestic goats and sheep.

Thirty years ago, a thinly settled buffer zone protected the ecosystem from the pressure of agricultural activity. But as people have pushed in and multiplied, grazing and cultivation have moved in some places onto the very border of the park.

No matter how much you love wildlife, can you justify an animal Eden such as the Serengeti on a continent where hundreds of thousands of human beings are starving to death? No conservationist I met doubted it for a moment. Nor do I. The glory of life is visible in the Serengeti. To conserve it, even as a living museum, is desirable.

But conservationists, like money, generally come from outside Africa, and Africans who share living space with wild animals are not usually sentimental about them. "Why should the rural African look after creatures that could potentially destroy him—eat his domestic animals' forage, drink his water, wreck his crops?" Finn asked. Yet the tourist pays money to look at the animals, and there is benefit in that.

As conservationist, as poacher, as competitor for space and food, man is part of nature and part of the Serengeti ecosystem. Like the elephant, he would be happier elsewhere, and he is responsible for a certain amount of damage. But is he more an enemy of the rest of nature than is the elephant? Like all the other creatures, the human being faces the problem of survival. In the management of this problem lies the answer to the question of whether the Serengeti as we know it shall or shall not die.

SOME LIKE IT HOT. A European white stork hunts insects and other prey fleeing a blaze set by park personnel. Some species benefit from managed fires. Poachers and herdsmen set many others. Generally, the Serengeti's face emerges fresh and renewed.

Among the research materials Markus Borner had given me was a slender Serengeti Park guide, published by the Tanzanian government in 1968. I had not found a moment to read it until my plane ride home. Now, too keyed up after my time in Africa and too tired to sleep, I opened the booklet. It was still admirably accurate—despite all the fears for its future, the park was recognizably itself after 17 years.

But I could not concentrate on facts and statistics, however comforting they might be. I found myself remembering the great black-maned lion, as pure of line as if he were carved on an Assyrian tomb, that I had watched along with the four lionesses on my first day on the plain. In my mind I had seen him again and again and given him a name: Yesterday's Lion.

How I missed him already. Will he still be here as tomorrow's lion? Or will he too survive only in memory—like all the other hostages and casualties to the progress of civilization? □

Rising, Shining

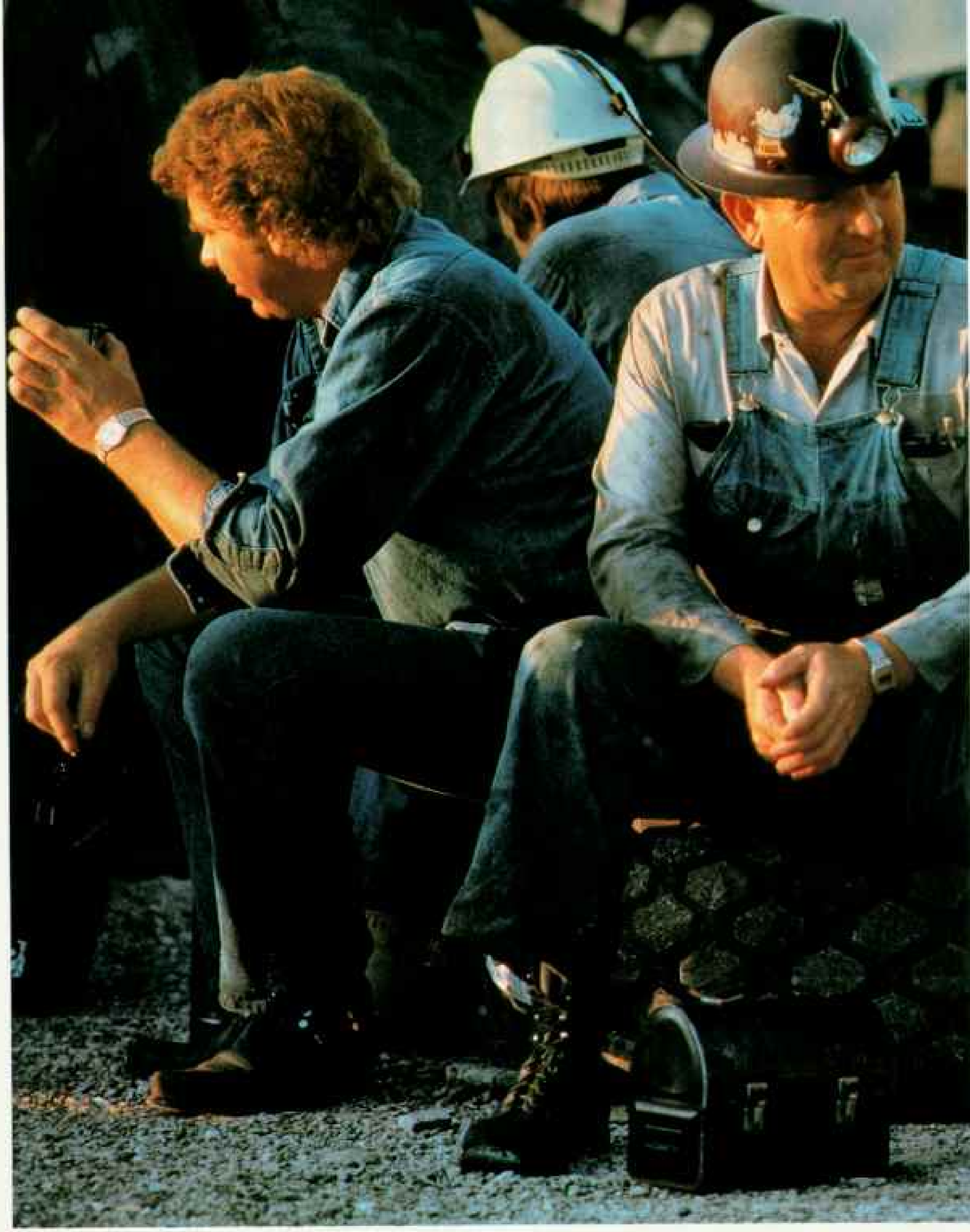
By PRIIT J. VESILIND
NATIONAL GEOGRAPHIC SENIOR WRITER

Photographs by
KAREN KASMAUSKI

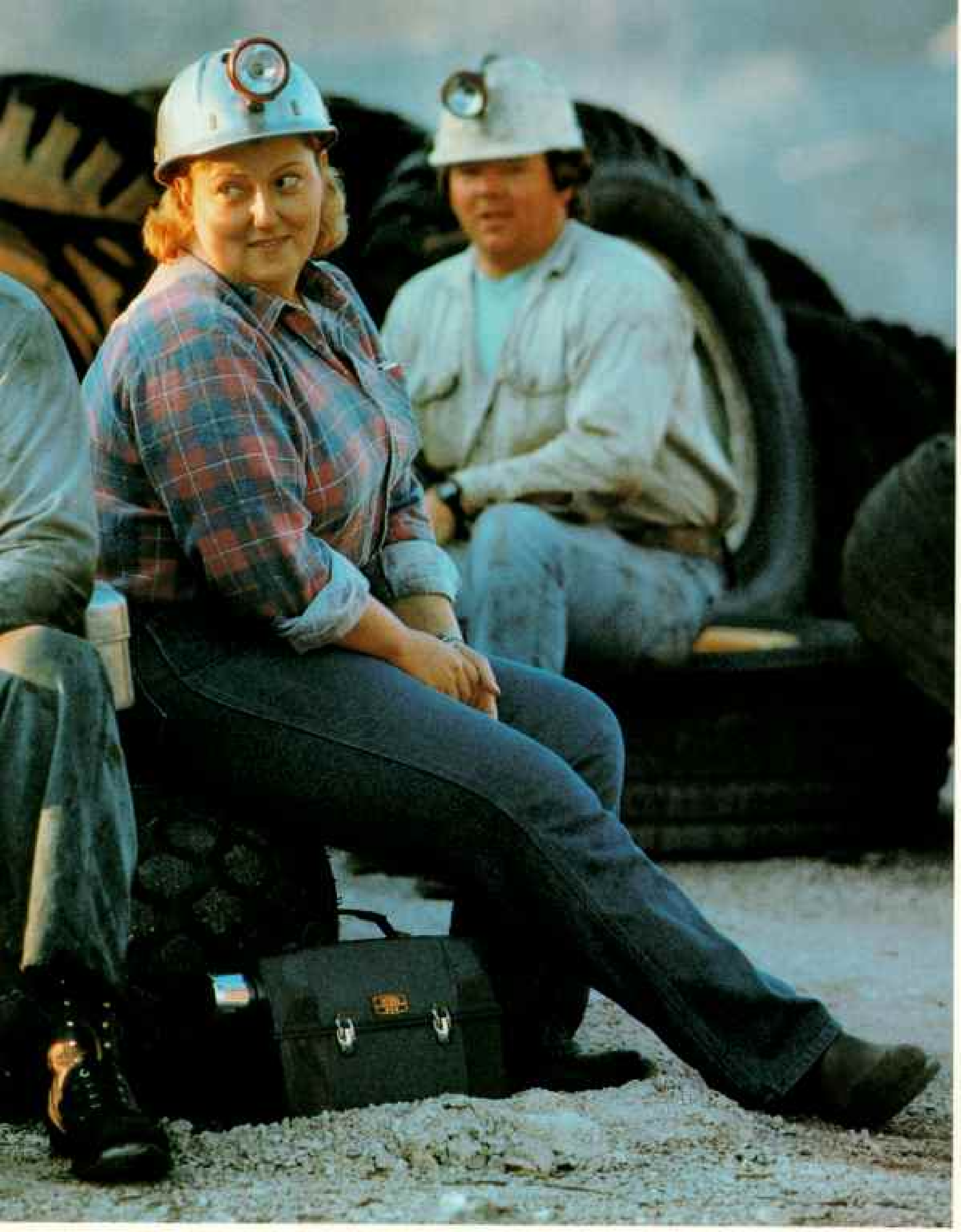
This land beyond the mountains has come far since it was colonial America's howling frontier—since the Civil War tore it apart with battles like that reenacted at Parker Crossroads. Here an early morning celebrant unfurls the Stars and Bars, original flag of the Confederacy.

Today, like the country boy made good, Tennessee greets the dawn with a sophisticated eye. Business is booming. Yet in many ways its soul remains unchanged from earlier times. And in a world increasingly hungry for yesterday's values—hard work, loyalty, love of place—Tennessee's frontier virtues may well be the secret of its newfound success.

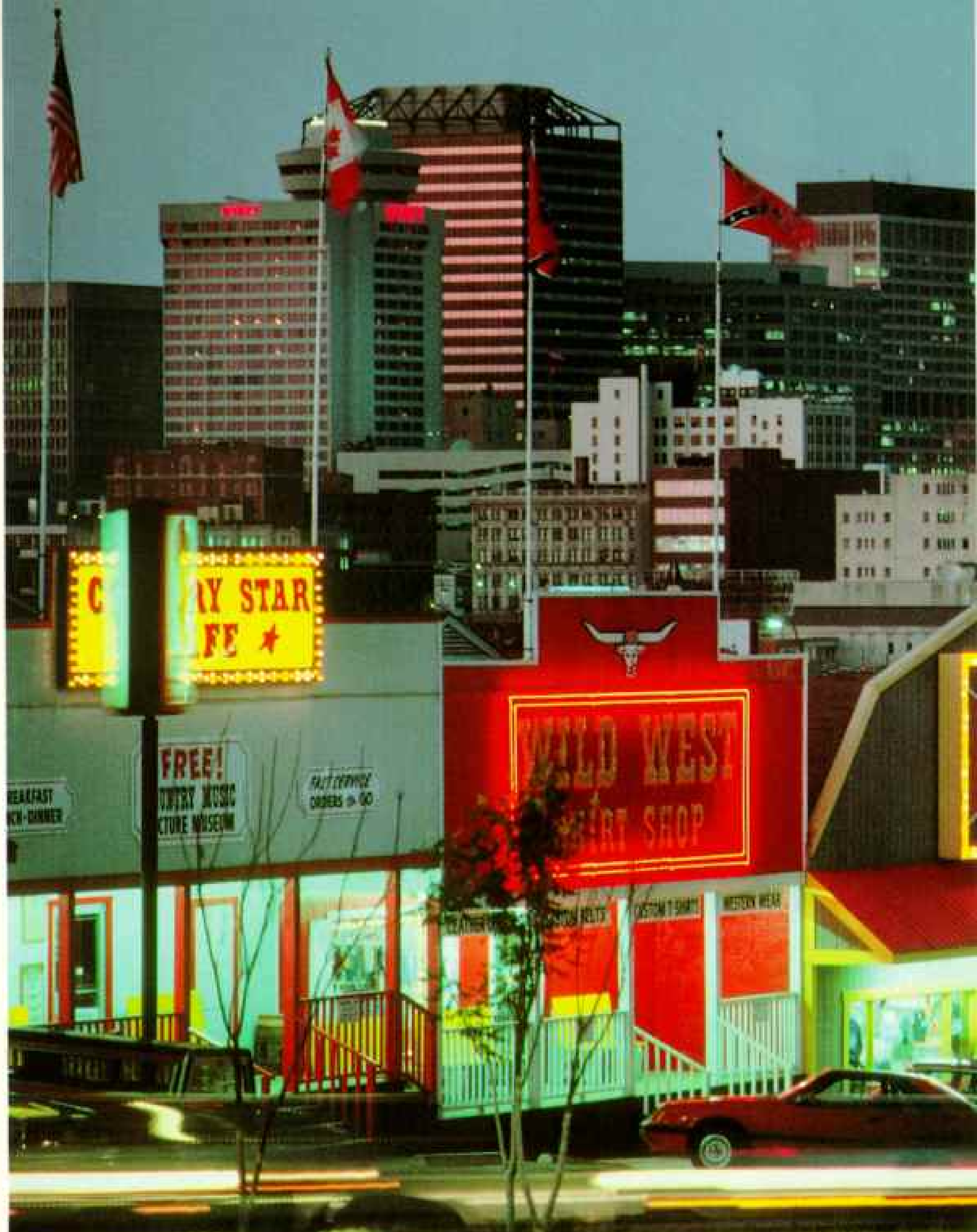
TENNESSEE



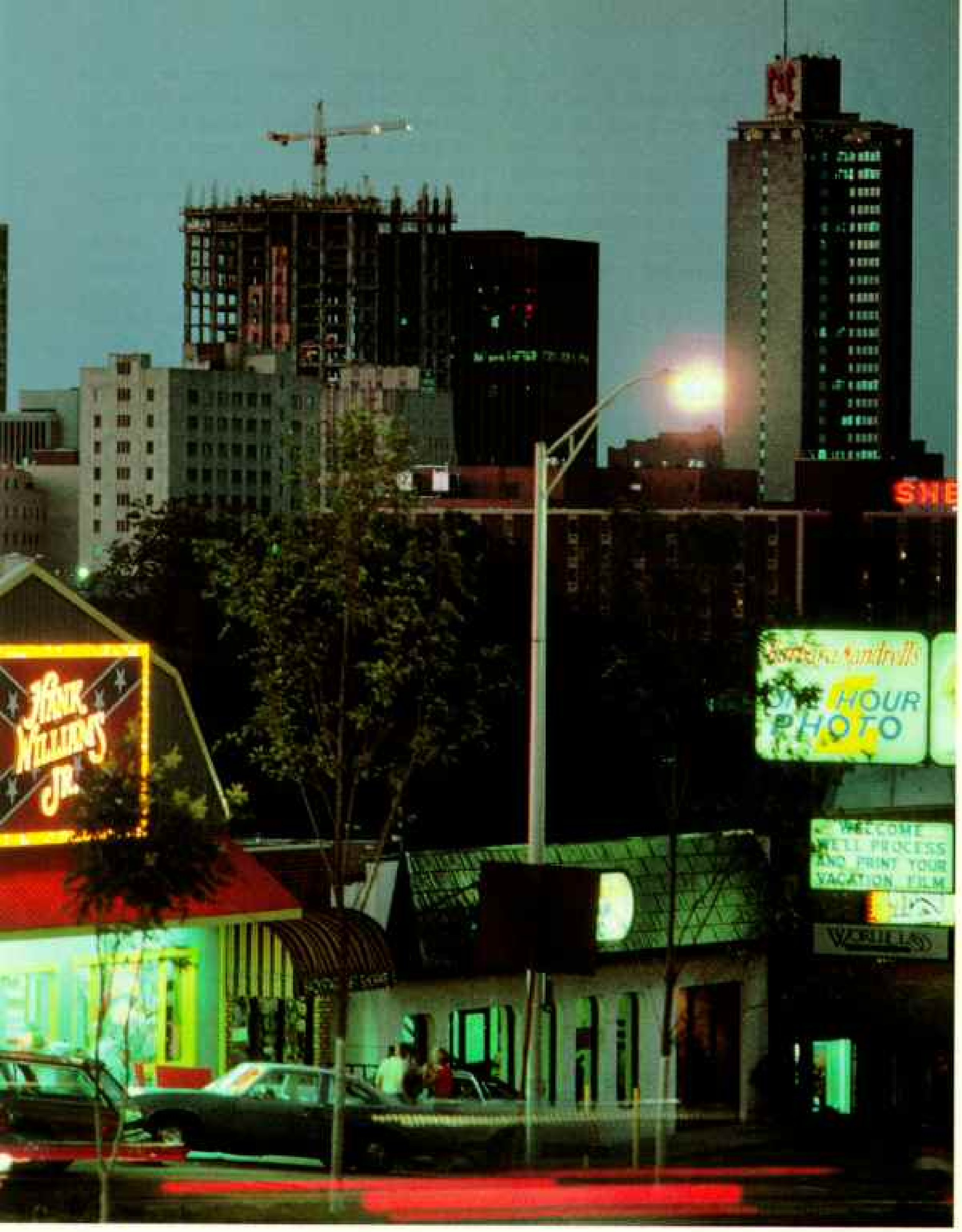
Superstition held that women brought bad luck to the zinc mines of east Tennessee, but roof trimmer Carolyn Wood changed all that when she showed up for work



eight years ago and "just decided to stay." Even so, old ways die hard in these mountains. "I still get kidded quite a bit," she says. "But not like at first."



Mecca for musicians and tourists, Nashville shows a businesslike skyline rising above the glitter around Music Row. Likewise, Tennessee's economic profile



grows higher as industries flood in, citing the state's centralized location, favorable business climate, ready work force, and traditional life-style as plus factors.

A GREEN APPLE fell from the tree of Randell Cottrell and settled in the grass. "If the earth was round and spinning, like the scientists claim . . . ," mused the 76-year-old stonecutter, who had lost one thumb to a sawmill, ". . . and we was going around the sun . . . wouldn't we turn over?"

Randell's eyes drilled holes in my self-assurance.

"How's the water gonna stay in my lake down here if it's turned over?"

"Gravity?" I ventured.

"Hah! That can't even hold a dandelion seed down. How's it gonna hold down something heavy like my truck? They's something wrong."

A defiant logic operates among the people of the Cumberland Plateau in eastern Tennessee. Men like Randell Cottrell spend their lives laboring in these mountains, quarrying the prized Crab Orchard building stone left in layers by the rise and fall of ancient waters, and they place their trust in a forceful Creator.

"God knowed that fellers like me had to make a living," Randell said, "and He knowed somebody was gonna work the rock. That's why He left it in layers.

"You know, back when I was a lot younger, I would work until I could hardly move. I loved it. I always wanted to see what was under that other layer of stone. And my wife said, 'Randell, you got no sense. You're killin' yourself and don't know it.'

"I said, 'Well, I just gotta work.' You may think I'm lyin', but I hated to see the sun go down. The days weren't long enough."

Forty miles from Randell's home, in the city of Oak Ridge, some 1,500 Ph.D.'s mull over the nature of nuclear energy. They labor in the laboratories that made uranium 235 for the first atomic bomb. They too are searching for the next layer, the other side.

But those scientists who landed in rural Tennessee in 1942 came to understand one thing clearly: It was no place for transients, but a region that demanded stiff credentials for belonging. Newcomers were foreigners in Tennessee and remained so.

A dogged regionalism survives, but America, the standard version, has finally swept pea-pickin'-poor Tennessee into its mainstream. Today's Tennessee feels good about itself. And it's searching, says Governor Lamar Alexander, for ways to welcome new technology and new people without losing the grit, the faith, and the common sense of yesterday.

"A lot of progress passed us by over the past 40 years," he told me, "and Tennesseans felt a bit intimidated by that. The irony is, Tennessee suddenly got fashionable. Our values, which are yesterday's values, are now the values that many people yearn for. And people are moving here for that reason."

There is another, less emotional factor. Tennessee is wedged between the nation's North and South, and stretches between East and West. When the American population began its shift to the Sunbelt, Tennessee emerged as a market center, only one day's drive from populous eastern and midwestern cities. Industry has moved in swiftly.

Last summer General Motors chose Spring Hill, Tennessee, population 1,100, for the biggest single industrial investment in U. S. history, its new Saturn automobile plant. The production date for the new subcompacts is 1990.

Nissan trucks began rolling from the lines at Smyrna, near Nashville, in 1983, cars two years later (page 611). Nearly 10 percent of Japanese investments in the United States have now located in the state.

A high-technology corridor, strongly supported by the University of Tennessee and the national nuclear energy facilities, percolates between Knoxville and Oak Ridge. A model "career ladder" program, in which better public-school teachers get better pay, is being emulated by 26 other states.

Memphis has picked itself up from the Mississippi mud to challenge Atlanta as the medical research center of the Southeast. Nashville has grown sleek as the "third coast" of the nation's music industry.

But don't look for state consensus. Tennessee divides itself, surely and accurately, into three parts. The mountainous east is hickory-smoked Appalachia, conservative, Republican, and down-home. Middle Tennessee is pleasantly tolerant, rich with horse farms and the slow roll of white rail fence over pasture. And flat, cotton-pickin' west

Tennessee, sir, belongs to the Democratic Party and the Deep South.

"We've had generations of politicians try to stick us together," Governor Alexander told me, "and we don't stick together. We ought to just celebrate our differences."

To make his point, the governor has launched Tennessee Homecoming '86. Almost every community in the state has organized a concert, craft show, fair, or festival, and invited its native sons to come on back home. Things are OK again.

I drove into Tennessee from the east in a pouring rain, through a four-lane cleft in the Appalachians, on a spring day when the mountains lay under a pea-green quilt of broadleaf forest and pillows of vapor hung in the hollows. Semitrailers roared along the interstate with hardwood logs and crates of pigs. Gatlinburg resort rested between winter's skiers and the throngs of summer.

In my three months of travel through Tennessee, the homecoming hoopla wore thin; every economic transition scatters losers among the winners. Especially in the west, the cheerful slogans of Nashville grated against the reality of hard times. But Tennessee is building on bedrock—the sense of belonging, the sense of place, and the character of its people.

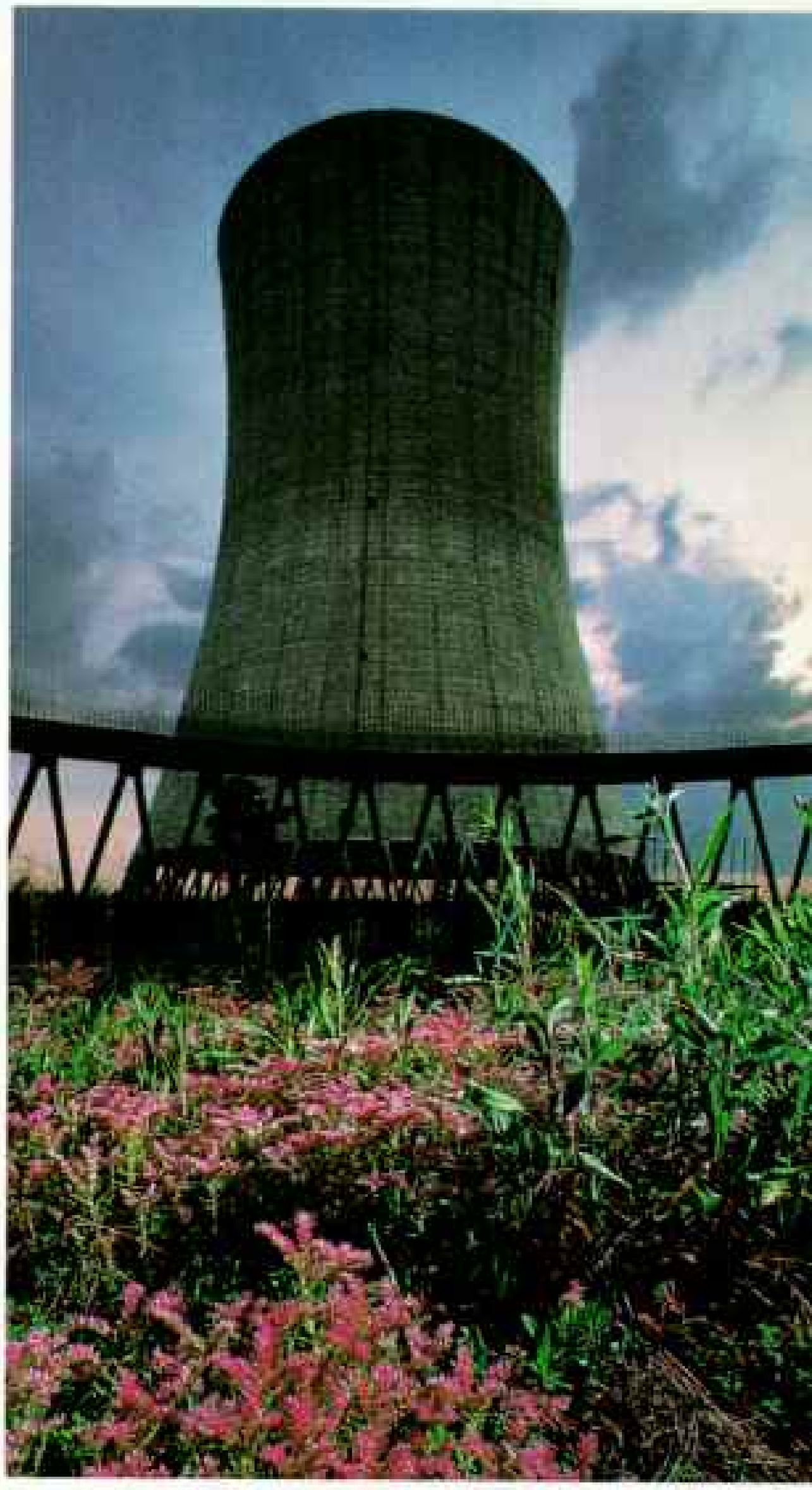
The state falls like a giant slope to the west. It's shaped rather like Wyoming, after someone had stepped hard on it. The town of Kingsport, in the northeast corner, is closer to Canada than to Memphis (map, pages 612-13).

That's where I found Clarence "Snake" Grills, a true east Tennessean. Snake (his mother calls him Junior) can do just about anything: butcher a pig, fix a truck, catch a bass, pick a guitar.

His wife, Pam, can do all those things too. Except she plays the string bass. Add a few neighbors with a banjo, a fiddle, and a mandolin, and you got yourself Snake and the Grass—their own bluegrass band.

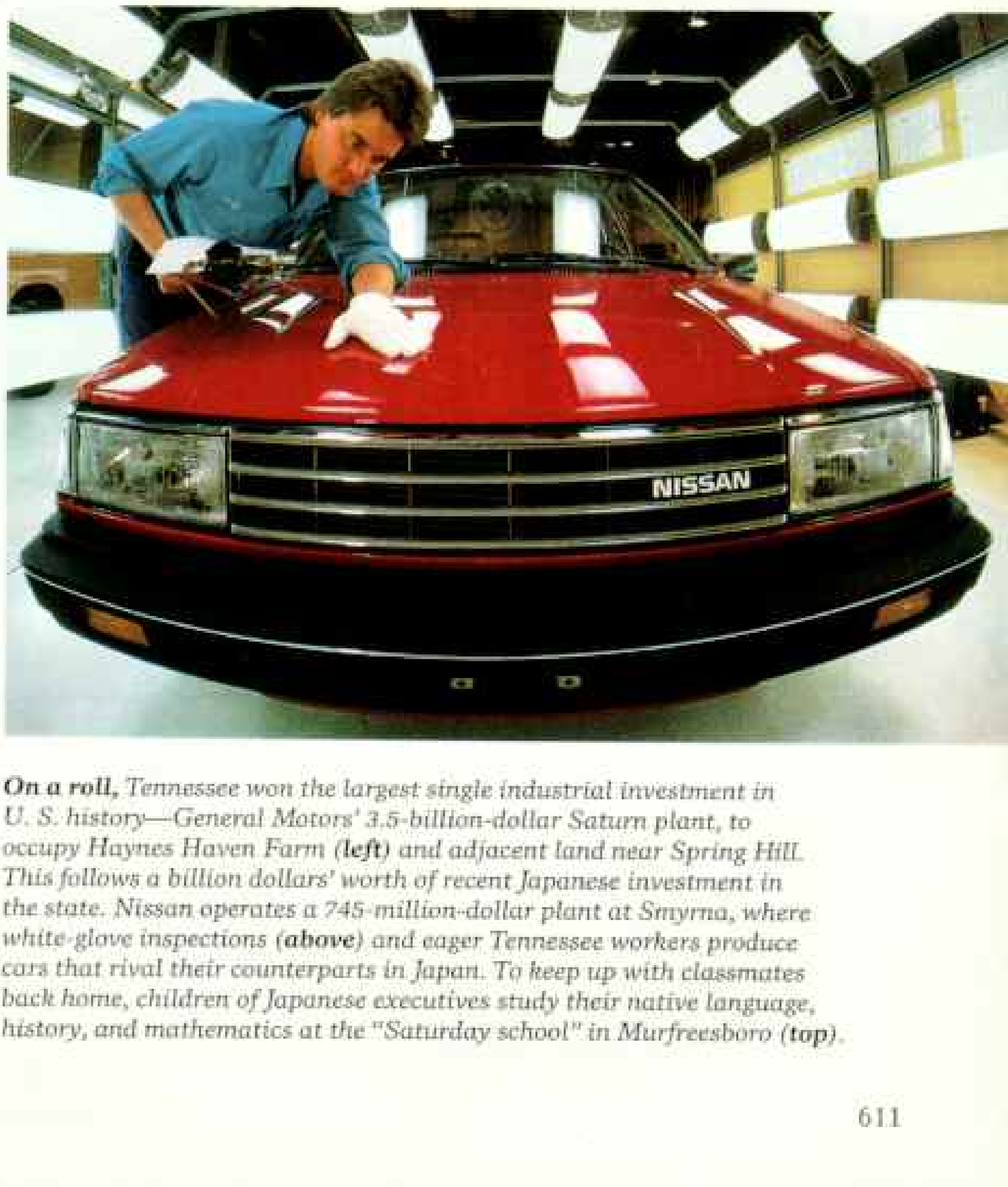
Snake works at the Eastman plant in Kingsport and runs Grills Pig Farm, along with his daddy, "Wimpy."

"People here have always worked," he told me. "Sometimes it's real bad on night shift, when I have to kill a hog and make



An ominous shadow *hangs over the Tennessee Valley Authority's nuclear program, including this cooling tower at TVA's Hartsville plant, where construction was halted in 1984 because of high building costs, local citizen protest, and falling energy demand. If completed, the four-unit Hartsville facility would have been the largest nuclear power plant in the world.*

One of the first utilities in the nation to invest heavily in nuclear facilities, TVA is not now generating a single kilowatt from atomic sources, despite a cumulative investment of some 13 billion dollars.



On a roll, *Tennessee won the largest single industrial investment in U. S. history—General Motors' 3.5-billion-dollar Saturn plant, to occupy Haynes Haven Farm* ***(left)*** *and adjacent land near Spring Hill. This follows a billion dollars' worth of recent Japanese investment in the state. Nissan operates a 745-million-dollar plant at Smyrna, where white-glove inspections* ***(above)*** *and eager Tennessee workers produce cars that rival their counterparts in Japan. To keep up with classmates back home, children of Japanese executives study their native language, history, and mathematics at the "Saturday school" in Murfreesboro* ***(top)****.*

sausage, sleeping only three hours a day. But we have to have a good sense of humor."

Snake gets homesick when he leaves for more than three days. He can pick out most of his relatives' houses from his daddy's front porch, and he used to know every soul in a four- to five-mile radius.

No more. Said Snake to me one morning, squinting over the corn-tufted hills, "Twenty years ago you could stand here at night and not see any lights. You could hear the neighborhood drunk walking up the gravel road, and it would wake you up. Now the interstate's come in, and new people."

Many of the Scotch-Irish who struggled through the Appalachians in the late 1700s dug in before they reached bottom. Isolated by both geography and inclination from the eastern seaboard, they grew inward and self-sufficient, like islanders.

Tennessee became a state in 1796, the second west of the Appalachians. It proved its commitment to the Union during the War of 1812. In the Mexican War, asked to volunteer 2,800 soldiers, Tennessee sent 30,000, forever clinching its nickname, the Volunteer State.

By the 1830s the good land was nearly gone, and new settlers, trying to farm hills too steep for a plow, began their migration west. Those who stayed in Tennessee sank iron roots. Even when automakers sent buses to haul jobless "hillbillies" to the assembly lines of Detroit and Gary in the 1920s, the stubborn ones stayed to plow on.

But the northern factories folded in the Great Depression, and the plots back home, now split among many brothers, were too small to support families. Massive federal aid programs—the Tennessee Valley Authority (TVA), the Civilian Conservation Corps (CCC)—descended as if on a Third World country.

Folklorists, some with tape recorders, were fascinated by remnants of Elizabethan English, practical craftsmanship, and folk ballads traceable back to the Scottish Highlands of the 16th century.

Today this Appalachian culture is fast becoming a collector's item. Television has supplanted the evenings of storytelling and singing on the back porch, and children, loath to be different, seldom talk of old times with their elders. But the ballads and fiddle tunes survive in modern country music.

Dolly Parton, a daughter of Appalachia, had a stretch of Highway 411 named for her, and that's the one I took toward Pigeon Forge and the area where she was born. Buckskin and western-wear shops line the highway. A mule stares from a weather-beaten shed. Black Angus cattle teeter cross-legged on a hillside. Small houses crouch beside the yellow flame of ripe tobacco, and plastic flamingos graze on their front lawns.

Between Sevierville and Gatlinburg the hype is on—caged bears, water slides, country music emporia, junk shops, and tellers of truth. Soon to come is Dollywood, a theme amusement park and personal shrine for Miss Parton in Pigeon Forge.

Private enterprise reaches its breathless peak in Gatlinburg, a boomtown for vacation trippers, and one of the nation's

TENNESSEE

BORDERED by the Great Smoky Mountains on the east and the continent's largest river on the west, Tennessee's lean middle is characterized by rolling hills laced with man-made reservoirs of the Tennessee Valley Authority. The 16th state's gritty spirit showed itself in

Backyard butcher, *Clarence "Wimpy" Grills hoses down a hog destined to become sausage. Now retired from his insulation business in nearby Kingsport, Grills keeps busy with the part-time hog farming he's done all his life. "It just gets in your blood," he says, echoing the many Tennesseans who hold full-time jobs but cling to their rural heritage by farming on the side.*

NGS CARTOGRAPHIC DIVISION. DESIGN: LISA BIGANZOLI. RESEARCH: DOROTHY NICHOLSON, LINDA PAYNE. PRODUCTION: MARTIN GOLDEN, BARBARA CARRIGAN

the War of 1812, and again in the Mexican War in 1846, when Tennessee was asked for 2,800 men—and 30,000 volunteered. It's been the Volunteer State ever since. Agricultural resources are limited, with more than half the state considered unfit or poor for farming. But a phenomenal parade of new industry invigorates what was once one of America's most depressed areas. Employment and income figures are up, nearing national averages.

AREA: 42,144 sq mi. **POPULATION:** 4,717,000. **MAJOR CITIES:** Memphis, 648,000, Nashville (capital), 462,000, Knoxville, 174,000. **INDUSTRY:** Chemicals, food processing, tourism, machinery, electrical and electronic equipment. **AGRICULTURE:** Soybeans, dairy products, tobacco, cattle, hogs, corn, nursery products, poultry.

Live and let live *is the prevailing attitude in Tennessee. And that's just fine with Mennonites living near Muddy Pond, whose beliefs call for doing things an older, simpler way. Howard Habegger* ***(right)*** *makes sorghum molasses for sale to tourists. He checks the consistency of juices squeezed from his horse-driven press—helped along by daughter Naomi* ***(below,*** *at left) and friend Deborah Horst. In the cane field, 12-year-old Rhoda Habegger* ***(facing page)*** *fashions a leafy bonnet.*

southernmost ski resorts. One drives through the Gatlinburg strip as through a gantlet in a morality play, to emerge into the purity of Great Smoky Mountains National Park.

For the world changes at the park entrance with a click, as surely as a slide changes on a projector. Suddenly, eerily, you stand in a cool, still cathedral of forest, among the rhododendron.

This is one of the largest publicly owned stretches of wilderness east of the Mississippi —500,000 acres of luxuriant high forest—an American Kashmir set within an overnight drive of half the nation's population. Visitors number nine million a year, three times that of any other national park. In the summer, the cars creep in queues along its arteries, thousands of hikers thread its 900 miles of trails, and lazy chains of inner tubers drift from rock to rock along its shady streams.

The dark side of the mountains is continuing poverty and unemployment, and a stubborn resentment of outside authority. This is where federal revenuers chased moonshine—that homegrown corn whiskey said to put hair on the chest and cure ills from lumbago to bad breath. But the high price of sugar has discouraged most distillers. The new moonshine is marijuana, the fourth leading cash crop in Tennessee, behind soybeans, tobacco, and corn. Each plant of the high-quality *sinsemilla* variety can mean $500 in street sales; a patch can mean prosperity for discreet backwoodsmen.

"These are not old hippies," said Maxey Gilleland, coordinator of the Governor's Task Force on Marijuana Eradication. "They're farmers, countrypeople. But we're working on people now making $100,000 a month."

Such temptations can even ensnare the law; four sheriffs have been convicted of drug violations since 1982.

The mountains of east Tennessee are also known as one of the nation's biggest cocaine distribution centers.

"Cubans and Colombians have come up from Florida, buying land here to build airstrips," said Maxey. "It's because of the ease of hiding among the valleys and nooks of the mountains. About two o'clock at night you might even see an airplane landing on the highway."

The valley of the Tennessee River, which trisects the state in a lazy oxbow before flowing into the Ohio, forms a natural arena for hydroelectricity. When TVA began transforming the watershed into a stairway of locks, dams, and lakes in the 1930s, it brought cheap power to poor people. It offered flood control, opened east Tennessee to the world with almost 1,100 miles of waterways, and brought new life to one of the nation's most severely depressed areas.

Today America's largest federally owned utility serves seven million people in seven states. Its power, now mostly from coal-fired plants to meet high demand, is no longer cheap, the people no longer poor. Some Tennesseans are sensitive about TVA's Big Brother image, and an ax-wielding Congress wonders why a regional program deserves federal funds. Now TVA's ambitious nuclear program has virtually collapsed, eroded by weak management, untimely accidents, tough new safety regulations, and forecasts of falling power demand.

TVA's more flamboyant blessing has been its 30 Great Lakes of the South, ideal for fishing, waterskiing, and houseboating. The agency operates 139 recreation areas, including the immense Land Between the Lakes on the Kentucky border, an experiment in multiple use of public land, where timber is harvested, crops sown, bald eagles nurtured, and buffalo allowed to roam.

Such government help has been vital to remote areas like the Cumberland Plateau, where the U. S. Army Corps of Engineers created one of Tennessee's purest and most beautiful lakes, the deep-blue Dale Hollow. Here, where other resources are slim, the recreation dollar keeps bread on the table and a satellite TV dish in the yard.

TVA's home is Knoxville, whose triumph was the World's Fair of 1982, the inspiration of charismatic financier Jake Butcher. The city cheered as Jake and his brother, C. H. Jr., played "country boys" in the fast lane, erecting a 3.2-billion-dollar banking empire, only to watch it collapse in 1983 under charges of manipulation and fraud. Jake tossed cold water on Knoxville, and the episode still stirs strong feelings.

Today Jake sits in jail, the slow lane, and the fairgrounds . . . no one is sure what to do

with them. A committee is working on it.

Still, many remember the heady days of Jake Butcher as if through a hangover.

"Jake wanted to put Knoxville into the 20th century," Oak Ridge resident Dorothy Walsky told me. "And he pulled people along kicking and screaming. He said, 'I'll go, even if you don't want to.' But now we have a lot of colorless people. We don't tolerate heroes here."

But Knoxville is blessed by lakes and mountains, and it was named one of the two most livable cities in the United States in a 1984 national survey. The University of Tennessee, one of the nation's largest land-grant universities with 25,000 full-time students, dominates its center. And at the Civic Coliseum the American Ballet Theater is coming. The marquee reads: "BARYSHNIKOV, PRO WRESTLING, HAVE A NICE DAY."

I find the ballet is sold out. In the lobby, men in blazers, freshly tan from golf courses, escort ladies beaming through their powder. An occasional black tie flashes past.

Celebrating the ramp, *Keith Baxter of Newport wears the onion-like mountain plant honored during the springtime Ramp Festival in Cosby. Some claim that ramps prevent colds—although skeptics feel that after eating the plant, which tastes like a cross between onion and garlic, "nobody would get close enough to give you one."*

The real heroes arrive in the fall when University of Tennessee football galvanizes most of the state. More than 62,000 season tickets are sold before the season starts.

Said coach Johnny Majors, "One of the great things here is that people who never went to college support us—because this is their school. This is their state."

From Knoxville I explore the Cumberland Plateau, driving in midsummer haze past tired barns and waves of black-eyed Susans sprung from the rubble of derelict cars. Chickens scratch in pebbles and dust. Maw and Paw set on the front porch rocking.

In the village of Moss, up near the Kentucky border in Clay County, the menfolk play with marbles carved from flint that lies embedded in the highland rim, on clay fields whose texture and thickness they watch as avidly as golfers eye the lay of a green.

Adult marble games were once known throughout the South, but the one called rolley hole has shrunk to a couple of hundred players in two counties, here and Monroe County, Kentucky. Tennessee's parks department built a rolley-hole yard beside a tennis court and swimming pool at nearby Standing Stone State Park. Local purists made sure they did it right. And Tennessee rolley holers were amazed when they went to play the Kentucky team in Louisville in 1984, because, one told me, "They held it on AstroTurf!"

To buy a proper marble, you climb Free Hill and call on Bud Garrett, blues singer, merchant of barbecued goat, grinder of flint, wheeler of deals (page 626).

Free Hill is a pre-Civil War black community established, local people will tell you,

when a woman came from Virginia and freed her slaves here on a rocky mountaintop. They lived by their wits, surrounded by indifference and casual hostility. There are stories of night riders thundering up the hill and raping black women in a kind of local puberty rite. But Free Hill survived. About 130 remain on the knob overlooking the Cumberland River.

"I think people have always felt a pride living here," said Bud Garrett. "Here we weren't pressed. We weren't part of the 'Niggertowns' that grew up in many southern towns. Oh no! Here was Free Hill!

"It was land that nobody else really wanted. We can barely raise a garden. I remember 60 years ago, we'd get the white people's ham bones and stuff they didn't need."

Garrett flashed a broad patent-leather smile and bent down to his grinding machine. The hard flint dust billowed around his head. Slowly, a gleaming white marble emerged—one that would cost a serious rolley holer ten dollars.

He looked up from the grinder. His oversize hands were shaking. "You ever work for a ham bone?" he asked. "Yessiree! Ten cents apiece for a ham bone . . . you can't *buy* a ham bone any more."

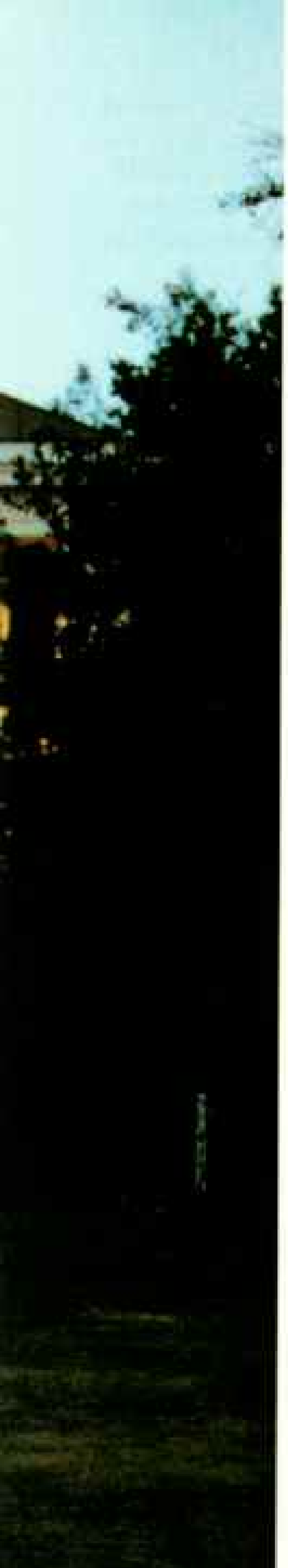
See Rock City. That simple plea, painted in block letters on barn roofs, summons travelers to Chattanooga. And I had resisted long enough. The drive from Knoxville follows the Great Valley between the Appalachians and the Cumberlands to the Moccasin Bend of the Tennessee River. Crazy Ed has his fireworks shop on this peaceful and scenic stretch. Rock City, and its partners in tourism, Ruby Falls and the Incline Railway, both of which the diligent traveler must also *SEE*, occupy Lookout Mountain, the rampart from which it is said you can *SEE* seven states. You can't.

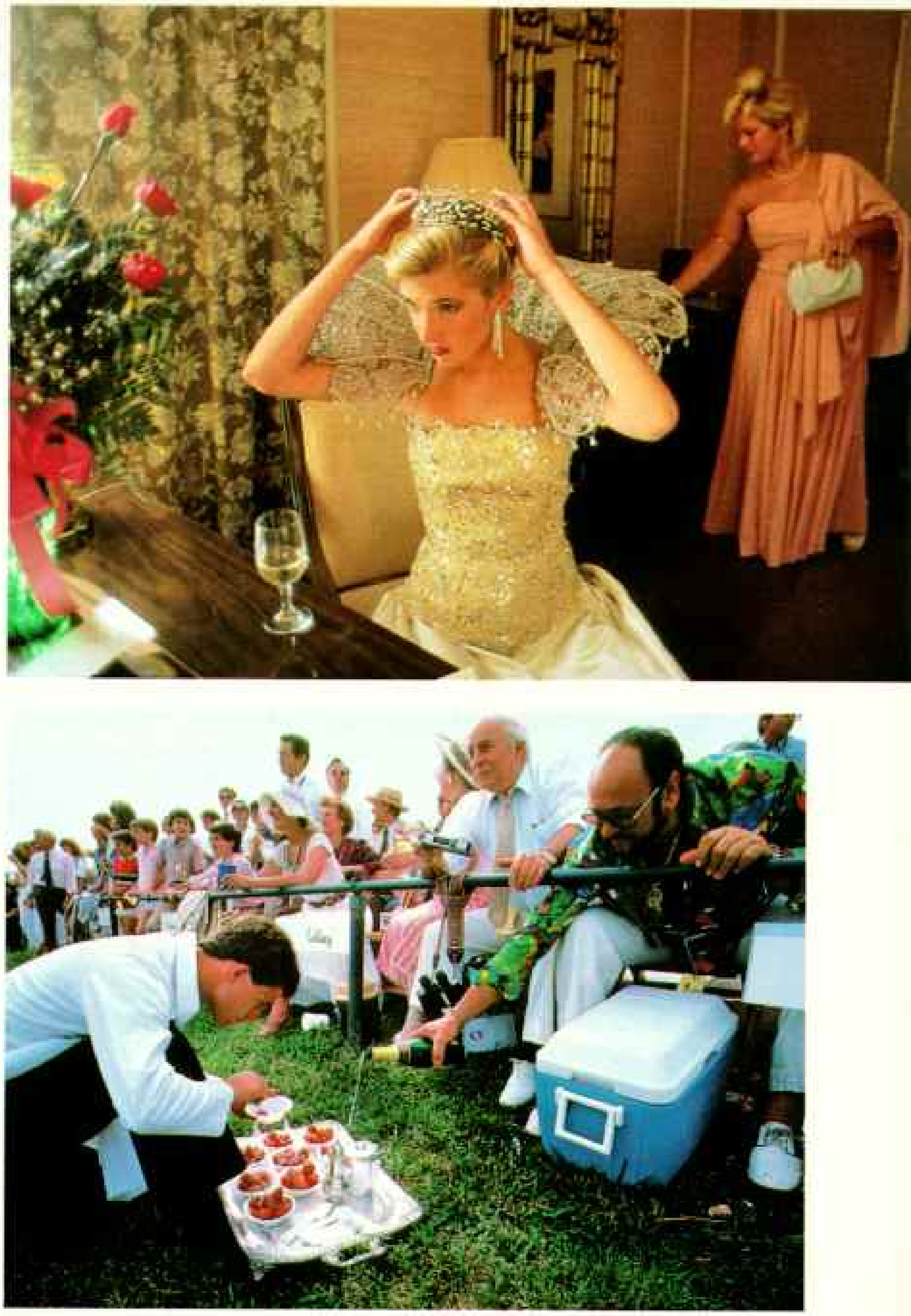
It required the automobile age to make Lookout Mountain a place to live, both for descendants of pre-Civil War families and northern soldiers who turned Chattanooga into one of the Southeast's centers of heavy industry.

Here philanthropy is the hobby, tennis the sport, and the annual Cotton Ball the chance to establish pecking order in the

Sealed with a kiss, *the bond between country singer Jim Hager of TV's "Hee Haw" (**below**) and an eager fan grows stronger during Fan Fair Week in Nashville, an annual face-to-face meeting of musicians and their admirers. Country music thrives on the personal touch and loyalty. "Once you have a fan, he's yours forever," say music insiders.*

*Even so, no one expected the outpouring inspired by Elvis Presley's death in 1977. Each year more than half a million visitors from around the world tour Graceland, Presley's home in Memphis. And a candlelight vigil past Presley's flower-laden grave (**right**), held annually on the eve of his death, last year attracted an estimated 4,000 mourners.*





The social whirl *takes center stage at the Iroquois Steeplechase in Nashville* ***(above)****, where some 40,000 gather each May to socialize and enjoy tailgate delicacies like strawberries and champagne. The race is named for a 19th-century Tennessee stallion. The state's horse country is famous for mansions like Rattle and Snap* ***(left)****, built in 1845 and named after a post-Revolutionary gambling game that brought an early landowner, Col. William Polk, his 5,648 acres in middle Tennessee. Toast of Memphis society as queen of the city's Great River Carnival, Mignon Coors* ***(top)*** *adjusts her crown before beginning a two-week reign.*

name of charity. Chattanooga's growing young hoi polloi, tongues in cheek, have responded with the Kudzu Ball, complete with king and queen, named for the common vine that overwhelms local roadsides.

Downtown Chattanooga, once grimy with leatherworks and foundries, has been rejuvenated, and travelers can sleep at the Choo-Choo Hilton, in plush 19th-century railroad parlor cars at the old yard where the Chattanooga Choo-Choo once steamed in daily—from Cincinnati rather than from New York City and Baltimore, the route of the popular song.

I headed west along the state's southern rim into the central time zone, past the town of Sewanee, where honor students at the University of the South wear Oxfordian robes to class and hundreds gather for summer classical music camps.

From those lofty heights the road plummets off the Cumberlands into rolling forestland, sliding into middle Tennessee, a place of gentle people. While the social fabric of the mountainous east was rent by the hand of the federal government, middle Tennessee held on to its old virtues and its old sins. "The War" here is the one between the states. The Ku Klux Klan found its murky beginnings here, in the town of Pulaski.

Limestone underlies much of middle Tennessee, filtering water for the Tennessee whiskey made famous by the self-styled rustics of Jack Daniel Distillery in Lynchburg. Lush green lawns seem to spread in front of every home, and crickets sing in pastures of bluegrass. Antebellum mansions like Rattle and Snap, on land once lost in a game of chance, hide behind giant oaks. In Shelbyville more than 25,000 people from throughout the world gather each August to celebrate the Tennessee walking horse, the homegrown breed whose popularity with the wealthy helped pull middle Tennessee farmers out of the Great Depression.

Now middle Tennessee is on a roll. The dice are clicking; the action is in Nashville.*

Ah, Nashville! Thou art opportunity. People come here, as to New York and L.A., to MAKE IT.

Confident men in gray suits and button-down collars march briskly between gleaming city towers, while Fisk and Vanderbilt Universities incubate a sterling generation to follow. Mansions line the streets of Belle Meade, Tennessee's wealthiest community. In nearby Williamson County, Anglophiles in red jackets chase the inedible cross-country, blowing horns.

But music is Nashville's heart. Five thousand songwriters, many of them waiters or clerks ("temporarily, of course, ha ha"), agonize over their craft here. "The Nashville sound" of country music, suffering in revenues and interest for the past two years, may be yesterday's soup. But Nashville's music industry, spread in all popular directions, prospers. More than 200 publishing firms and record companies squeeze into the 14-block district known as Music Row.

I sat in on a "writers night" at the Bluebird Café one evening, where hopeful composers test their own songs.

"He's the only country singer left in Naaash-ville," one wailed. "They've all gone to rock and ro-o-o-ll!"

Even the conversation at the bar sounded like lyrics. "I'll be tender with you," said a man in a white suit to the blonde beside him.

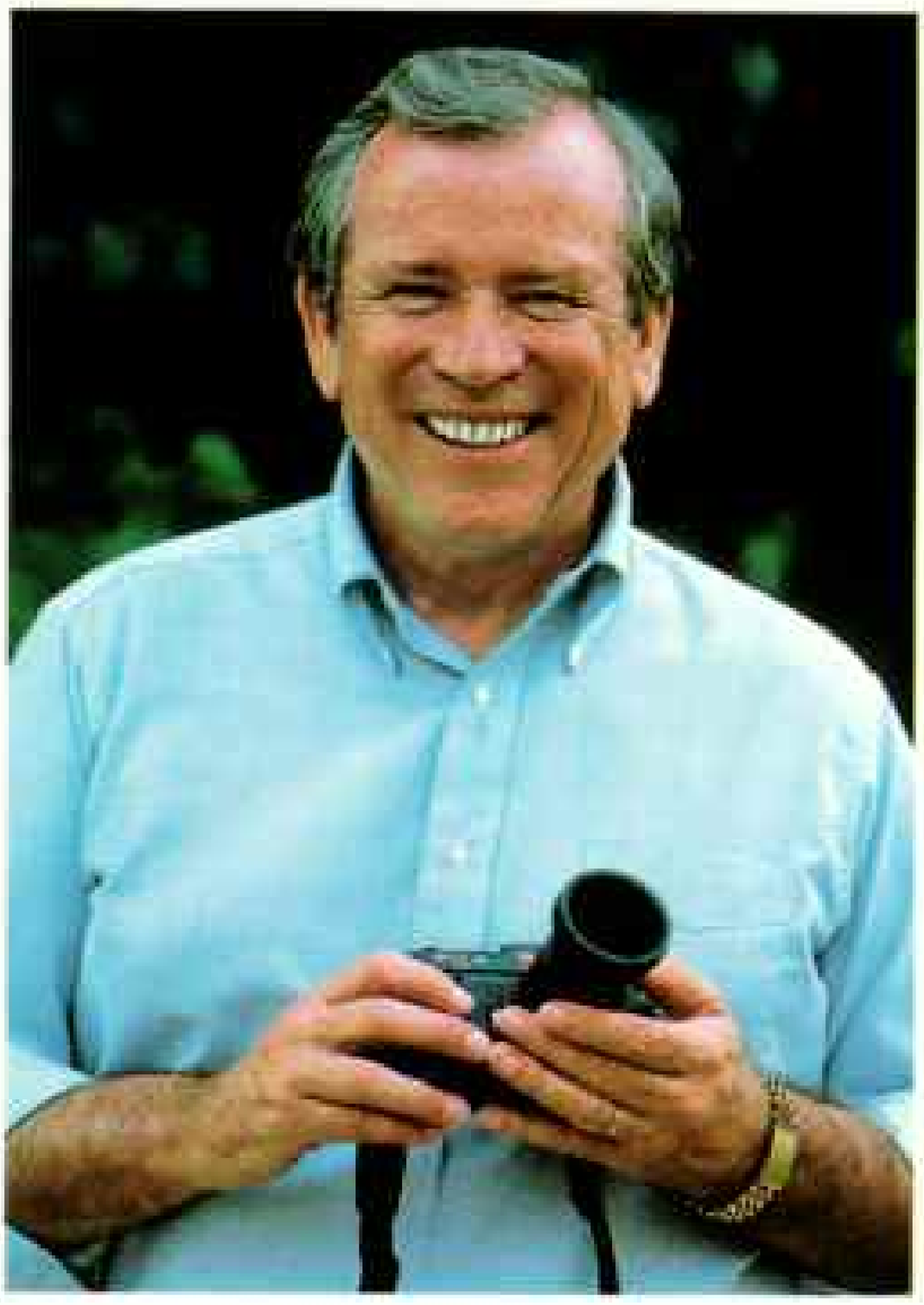
Old Ryman Auditorium, former home of the country music radio show called "Grand Ole Opry," is deserted. Tourists can still walk through the hall and stand where Hank Williams once stood, but the Opry has gone suburban, 14 miles upriver to a pleasant and highly successful musical theme park called Opryland, U.S.A.

Country music fans are aging, but devoted. At Twitty City, where Conway Twitty has built homes for his family members, fans will line up at 8 a.m. to see if the rascal will emerge in his pajamas to wink at them. At Barbara Mandrell's personal museum they will gratefully regard her bathroom fixtures and bedroom suite displayed behind glass.

At Broadcast Music, Inc. (BMI), on Music Row, one of only three agencies in the nation that represent composers and publishers in copyright matters, I talked to senior vice president Frances Preston, who started at BMI as a receptionist 25 years ago.

"It's very difficult to break into the music industry," she allowed. "You have a better chance of being a senator or congressman than you do of being a number one artist.

*See "There's More to Nashville than Music," by Michael Kernan, NATIONAL GEOGRAPHIC, May 1978.



Tennessee roots *provide a strong foundation for two of the state's favorite sons. The family tree of Huntsville's Howard Baker* ***(left)****, former U. S. Senate Majority Leader, has sprouted politicians for three generations; Baker's father and stepmother each occupied a seat in Congress. Baker left the Senate in 1985 to consider running for the Presidency in '88.*

"Tennessee is so, so special," says Roots author Alex Haley ***(above)****, shown on the porch of his childhood home in Henning. Haley recently moved back from Los Angeles to a farm near Knoxville. From there he serves as cochair, with comedienne Minnie Pearl, of Homecoming '86, Tennessee's year-long festival billed as "part reunion, part history lesson, and part good old-fashioned hoedown."*

On a breath of air, *a fancifully decorated hot-air balloon flown by Erma Woods drifts over the mist-covered landscape of northeast Tennessee. Balloonists favor the gentle, predictable breezes encountered over this part of the state—a moisture-rich region underlain by limestone and dominated by small livestock and tobacco farms.*

"Still, the song is the thing—the good song. It doesn't matter where it comes from, it doesn't matter who you know. The rags-to-riches stories are still realistic."

The rags of Nashville seem to congregate on lower Broadway by the river, in a five-block backwash of adult bookstores, pawn shops, hustlers, and honky-tonks where your feet stick to the floor.

That's where I found Celinda Pink in a floppy black hat, playing electric bass with a blues trio at the Hitching Post. There was no cover charge. An empty pitcher sat on two milk crates before them, for tips.

"They've got plenty of stars in Nashville," she told me during a break. "They don't exactly need any." Celinda ground out her cigarette, eyed me warily, and went back to work. Twelve years on lower Broad can turn anyone cynical. But when Celinda Pink leans back and belts out a song, eyes closed in a private high, it makes you wonder . . . just one more phone call, one more turn of the screw, one good break.

In and out shuffle the indigents, the dope peddlers, pimps, and prostitutes. She plays to them just now. They know the blues, after all. But do they like her music?

"Those people are the hardest to please," Celinda said. "They hate everything."

"Music is a series of long shots," said Lois Riggins, the bright, irreverent director of the State Museum of Tennessee. "But we are a city of dreams. You could almost have a songwriters' night at Union Mission, because so many people come to Nashville who think they can ride the wave, be near the heartbeat. They got a trunk full of songs and a heart full of memories, and not jackcrap in their pockets. But they do believe that some day they're going to make it."

"Lord, how I want to go home," sings Bobby Bare in his homesick country tune, "Detroit City." "By day I make the cars, by night I make the bars." Today's Tennesseans can do all that without leaving home.

I chanced into bucolic Spring Hill, 32 miles south of Nashville, on the day General Motors decided to put its Saturn plant on sprawling, manicured pastures of Haynes Haven, a large pre-Civil War horse farm just outside town. Network television crews had already descended. A CBS helicopter squatted on the front lawn of the Presbyterian Church, and camera crews poked lenses into windows of pickup trucks stopped at one of Spring Hill's two traffic lights.

The citizens appeared rather stunned, knowing their lives would soon change forever. Land prices soared in minutes. Speculators roamed the streets.

At the Gulf station Ann Russell groused halfheartedly, "If I wanted to move to Detroit, I'd move to Detroit. I don't want Detroit coming to me."

Economists believe the decision to build the subcompact Saturn represents a showdown between Detroit and Japan for America's small-car market. To compete in Tennessee's traditionally nonunion atmosphere only 30 miles from Nissan's nonunion plant, General Motors has signed an innovative labor agreement with the United Auto Workers, guaranteeing the union a voice in the Saturn plant's operations.

Five years ago Spring Hill captivated Peter and Barbara Jenkins, whose books and GEOGRAPHIC articles* about their walk

*The Jenkinses' articles appeared in the April 1977 and August 1979 NATIONAL GEOGRAPHIC.

A big boy's game, *once played by adults throughout the South, marbles is still popular in Clay County. Devotees shoot custom flint marbles crafted by Bud Garrett (**below**) that fetch $5 to $10 apiece. Adults play a traditional game called rolley hole, which emphasizes team play and strategy. The carefully groomed marble yard in Moss (**right**) has lights for night play.*

across America endeared them to thousands of readers. They live here now, on a 200-acre farm with their three children.

"The people are already here, rooted deep," said Peter, as we ate country ham and grits in the Poplar House restaurant. "People who believe in themselves, who can do anything, fix anything, work anything. That's why the car companies are coming.

"But now Tennessee is at a crossroads. It has to make a choice: whether to become a Michigan or Ohio, or to keep the qualities and values that make it special. Are my children going to grow up and say, 'I've got to get out of here'?"

The future is now, up the road at the Nissan plant in Smyrna, where each month 15,000 Sentras and pickup trucks roll into the American economy.

In a wing of an E-shaped building the size of almost 60 football fields, robots jerk like giant insects, flexing, spurting arc welds, unflexing. Plant President Marvin Runyon, white-haired, confident, precise, appears in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***Labor of love** comes to a welcome end for Lisa Chandler and her newborn daughter Natasha **(left)**. Tending to the pair is Ina May Gaskin, head midwife at the Farm, a cooperative community near Summertown that offers registered midwife care to its neighbors.*

*That's a tradition established by granny midwives such as 88-year-old Etta Nichols of Del Rio **(below)**, who learned the trade by tagging along with her father, a country doctor. She has delivered more than 2,000 babies and "won't retire till my toes are stickin' up."*

the interview room wearing a work shirt and pants, with his name-label sewn above the pocket. His is a hands-on policy.

"The power is gained from being approachable," he told me, tapping shrewdly into the local tradition.

Runyon pointed proudly to his record: "The quality of the products we're making here is equal to or better than those coming from Japan. That says, to anybody who wants to know it, that Tennesseans are capable of doing quality work."

Pickup trucks should sell well in middle Tennessee. Driving south again, I see them idling under shady trees in the evening. Men in overalls lean against their sides, just the right height for elbows.

Past and present seem to argue along the roads that link small towns here. Rented marquee signs flash their yellow arrows at tanning salons and videocassette shops. Near Lawrenceburg I nearly butt the back of a horse and carriage—a stolid Mennonite family from a settlement near Ethridge.

Ten miles west of Lawrenceburg the land seems to straighten out into large dairy farms. In Waynesboro I see men playing checkers in the window of a barbershop. A hound dog melts on the sidewalk. A boy of about nine wanders into the shop. His blond hair hangs shaggy over his forehead. He sits in the chair wordlessly. The barber stands back, feigning shock.

"How you doin', little girl?" he says.

Just short of Savannah, pine trees creep into the broadleaf patches. The Tennessee River loops back into the state, an enormous expanse of water where the brown floodplains of west Tennessee stretch into swampland sweet with the smell of honeysuckle.

"Onward Christian Soldiers" plays on the radio from Selmer as I roll across the soybean fields toward the hallowed battlefield called Shiloh, named for a country church.

I stood under the towering oaks that guard the meadows where 3,482 men fell in one of the bloodiest battles of the Civil War. They say the blossoms of peach trees danced like snow from the hail of bullets when Bowen's brigade, screaming their shrill Rebel yell, charged into Brig. Gen. Stephen Hurlbut's Fourth Division, Army of the Tennessee. And a ten-acre field in front of a Union stronghold called the Hornets' Nest lay so

Going downstream fast *are west Tennessee farms along Cane Creek—a small stream whose banks have been eroding since a 1969 channelization project. Conservationist Chester McConnell* ***(right)*** *fought the plan and watched his predictions come true, as attested by the now suspended fence. The area's soils, though highly productive, are light and easily lost to water runoff.*

thick with the fallen that, according to General Grant, you could walk across it without stepping on the ground. The wounded from both sides dragged themselves to die beside a small pond and gave it a name: Bloody.

For Tennessee, a divided state, the war was a heartsick affair. It was split between slave-owning planters and the small farmers, mostly from the mountains in the east. Families were wrenched apart. It was the last state to leave the Union, and the first to rejoin.

I had stopped at Pat's Café on Route 22, south of Shiloh, lured by the promise of the best catfish dinners in the world. There I met Woodrow Bryant, Pat's father, whose war was personal and not so long ago.

"My grandfather was in on that battle on the southern side," he told me, "and on my grandmother's side—they fought for the Yankees. She was nine year old then, and the day after the battle they took a wagon, tied it to a boat, crossed the river, and went out looking for her brother. There was bodies laying all over the ground. . . . Silliest thing ever was, the Civil War."

The rich hardwood forests that once covered the bottomlands of west Tennessee are nearly gone, and farmers struggle with row crops—cotton and soybeans—against an economic depression. The loess soil, windblown from the Great Plains, can melt like sugar in a pouring rain. West Tennessee seems oddly cut off from the rest of the state and does not share in the boom of recent years.

Silt from farmland runoff has nearly destroyed Reelfoot Lake in the quiet northwest corner of Tennessee, where nearly 200 bald eagles winter each year. You can watch them from the Airpark Inn, near Tiptonville, while eating a hamburger.

Reelfoot, a mystical world of cypress trees and stumps, was formed when the Mississippi River Valley was shaken by the New Madrid earthquakes of 1811-12. Eyewitnesses said the Mississippi momentarily reversed itself during the upheavals and flooded the depression of forest and swampland.

By 1920 a levee had been built to keep the Mississippi from flooding farmland around the lake. A spillway was added in 1931 to keep the level constant. But without natural rise and fall, Reelfoot stagnated.

Today the lake, long a paradise for fishermen and duck hunters, is dying of old age, in a state of eutrophication that should have taken thousands of years.

Emergency measures are needed, but wildlife agencies find themselves trapped in a tangle of local politics. An undercurrent of bitterness whispers among the lake people of Reelfoot, those who have lived here for generations on the hard edge of life, fishing and trapping, and doing what they damn well pleased. Some still remember 1908, when night riders rose among them in a campaign of terror against the landowners and their government.

When the Tennessee Wildlife Resources Agency, in an effort to revitalize the lake by simulating natural flood-drought cycles, began to draw down Reelfoot last summer, local outcry halted the project.

Lexie Leonard is a fourth-generation lake dweller who operates tour boats for the state. His outlook is glum. "If they drain it," he told me, "these boats are going to be tied up in the mud. They won't need me any more. And even if they don't drain it, the future of this lake is bad. We got a dying breed of people here that's going to die with it."

I drive south on the sediments of the Mississippi. Tractors plow the horizon like ships on a tranquil sea, pushing plumes of dust. Herons float across the moist furrows.

Erosion was inevitable when debt-ridden farmers turned their plows on land that

shouldn't have been planted with row crops at all—hillsides and forest areas that had held the soil together.* It was abetted by stream channelization projects designed to reduce flooding.

The Soil Conservation Service has helped farmers build terraces and sediment basins, and promoted no-till farming, in which seeds are planted in grass. But the problem remains critical.

"It's a national disgrace," said Chester McConnell of the nonprofit Wildlife Management Institute, as we drove a section of Route 51. "This part of Tennessee has the highest erosion rate in the nation, five times the acceptable rate of soil loss. It means very clearly that in 15 or 20 years you're out of business. You're at bedrock."

Channelization, Chester feels, is a prime culprit. He advocates the alternative of removing trees and other obstacles from the stream to ease flooding, allowing rivers to return to their natural meanders, and replanting vegetation to hold down the banks. But that can only be done at the cost of land that desperate farmers want.

"It's a highly emotional issue," said Chester. "At public hearings I'll always go in a suit and speak in a low, controlled voice and offer sound solutions. But I'll tell you, those people, you'd think you'd raped their wives and shot their kids."

We lunched at a country store, where Chester munched toasted pork rinds and washed down his exasperation with orange pop.

Later we met James Dunavant at his farm on a windswept knoll near the town of Ripley. A profusion of small factories, making products ranging from mufflers to Tupperware, has arisen around Ripley and soaked up the work force that farming has lost.

"The farmer? He's a dog—a peon," said Dunavant morosely as we sat around the kitchen table. "Always has been. The average factory wage is $18,000 a year. That equals farming 300 acres of land here. A lot of people are folding up and getting factory jobs. We have no farmers any more. We're part-time farmers."

Even those farmers who hang on send their wives to the factories. "Just about

*See "Do We Treat Our Soil Like Dirt?" by Boyd Gibbons in the September 1984 GEOGRAPHIC.

Taking a break from retirement, *64-year-old Claude Gaby* ***(facing page)*** *of Greeneville helps his son Teddy cure his burley tobacco crop. Leaves hang in a drying shed for several weeks, then are gathered and bound for auction.*

Tobacco income is small change to illegal marijuana growers in the eastern mountains, who have made Tennessee one of the nation's top pot producers. Concerned officials left growers in Cumberland County a message ***(above)****. In another raid they seized plants* ***(top)*** *worth $350,000.*

every house you'll find the farmer in the field, working," said Dunavant, "and nobody in the house."

Many despair and migrate downriver to Memphis and a steady paycheck. Memphis is a capital without a state, with nearly a million people in the greater city, but the urban center of a 200-mile radius that includes parts of Mississippi, Arkansas, and Missouri. To those in the Tennessee east, Memphis might as well be Dallas.

Twenty years ago Memphis was lost, a seedy river town with more memory than future. The assassination of Dr. Martin Luther King, Jr., here in 1968 accelerated the flight of white businesses to the suburbs. Vacant buildings were left to deteriorate. The music industry, Memphis's pride, eventually suffered.

Today the city can dream again. Its center shines with the requisite concrete-and-glass towers. Tourists are stopping, not just passing through. Biomedical and telecommunications industries have found an able work force. And city drawing boards overflow with hopeful blueprints.

The surprise leading industry is health care, foreshadowed during the Civil War when Union forces set up a 5,000-bed hospital. Memphis's medical research complex

A modern miracle *allows Lainey Marty* ***(below)*** *to "speak" despite cerebral palsy. Unable to talk or move because of her physical impairment, Lainey uses a wheelchair developed by the University of Tennessee, Memphis, to move independently and communicate. She picks out letters with a sensor keyed to head movements.*

The Mississippi once made Memphis ***(left)*** *the world's largest spot cotton market; today the city rides the crest of a biomedical and telecommunications wave.*

today includes the nation's largest private hospital. There are 4,000 physicians in Memphis, and a relatively high proportion of them are neurosurgeons. And now the city plans to convert a ten-block tract into a "biomedical research zone" for high-tech industries that complement the medical center.

William N. Morris, mayor of Shelby County, spoke passionately in his office high in the Memphis skyline: "Memphis is being reborn. Look at the airport. It's now become a major hub for Republic Airlines. They're running 160 flights a day out of Memphis. That's exciting, when you can sit here in this office and see a sky full of planes stacked up in the air waiting to land. And because of Federal Express flights, we're the busiest airport in the world at night."

But history left Memphis with a population half white and half black, separated by a wide gap. Whites feel pressure from the growing black population; some are uncomfortable with the city's image as the home of the blues, black music born of misery.

"Memphis has the potential to be very, very big," said musician and songwriter David Porter, who helped launch the "soul music" wave at black-owned Stax Records with his partner, Isaac Hayes, in the 1960s. "But it's only been using 50 percent of its assets."

The city and county governments have begun to respond, establishing a business

incubator center for new black entrepreneurs, which aids them with accounting, finances, and bureaucratic red tape.

Memphis music is coming back too, says the dapper Porter. "There are clubs in Little Rock, Arkansas, and Dallas, Texas. You know what they're called? Club Memphis! All they play is Memphis music.

"Our Memphis music has always been emotionalism in music. You *f-e-e-e-l* it. That's the strength of soul. You have to make the person *feel* where you *are*. And we have the way to do that."

From the days of minstrel shows and jug bands to the beloved composer W. C. Handy, father of the blues, the place to be was Beale Street, the boisterous, stewing sanctuary of south Memphis, where rural blacks flocked at the turn of the century, and where whites were welcome on Thursdays.

Most of the old Beale Street vanished with urban renewal, but has been revived as a sort of stage set, a three-block pedestrian mall with clubs and restaurants. The enterprise has struggled.

Memphis, where Elvis lived his bizarre and tragic American dream, has done big business on his death in 1977. An Elvis industry has mushroomed by popular demand around Graceland, Presley's mansion. In gift shops the faithful can buy, say, a grandfather's clock with Elvis's face on it for $3,000. Graceland contributes more than 50 million dollars a year to the city economy.

Each year on August 15, the eve of the anniversary of Elvis's death, thousands gather from all over the world for a candlelight vigil. David Beckwith, a Graceland public relations man, just grinned when I asked him how long this would go on.

"I keep thinking we're going to wake up some day and nobody will show," he said. "But it hasn't happened. It's a publicist's dream. You really don't have to convince anyone to come."

I joined the disciples that night in front of Graceland. We stood in the rain, cupping hands over candles while Elvis sang gospel songs over the loudspeaker.

"The heavens are crying," said a woman standing beside me, lifting her face to the drizzle. "I think it adds a nice touch."

The rain fell darkly on the city. It settled into puddles, trickled into rivulets over the cobbled streets by the old Cotton Exchange, and flowed into the Mississippi, a gray slate of water in the morning dimness, sliding toward other worlds.

Andes transplants *with padded feet and calm dispositions, llamas* ***(above)*** *pack supplies to the lodge atop Mount Le Conte in the Smokies. White-water fans* ***(facing page)*** *wait to raft the Ocoee River. Usually diverted to generate TVA power, the popular Ocoee is "turned on" periodically during the warmer months.*

Back on the Cumberland Plateau, Randell Cottrell had told me: "The Bible says the earth is held by four angels, one on each corner. Each one holds a wind."

And one angel has sent a fair wind blowing across the state of Tennessee. □


550
16

Shifting plates trigger two major disasters

When the Earth

CLOSE TOGETHER in space and time, catastrophes struck Mexico and Colombia last autumn. Within minutes they snuffed out more than 32,000 lives (many lost needlessly), inflicted billions of dollars in damage, and scarred the societies they touched.

Mexico's ordeal began 350 kilometers (220 miles) west of the capital when a massive earthquake sent seismic waves racing inland. They shook the teeming city, collapsing tall buildings and killing more than 9,000 people.

Two months later and 3,200 kilometers south, a minor eruption of a lofty Colombian volcano melted part of its cap of ice. Torrents of mud swept down the slopes and buried Armero and devastated other low-lying towns, graves for 23,000.

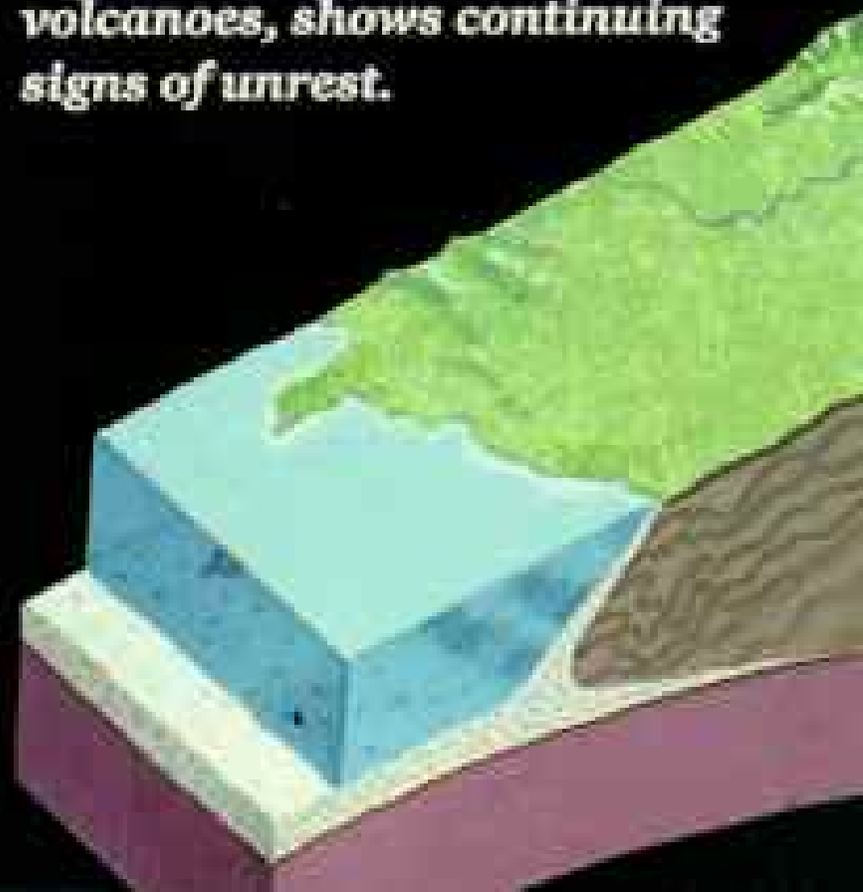
The events share a common origin. Mexico and Colombia lie along the Ring of Fire, a belt of intensive earthquake and volcanic activity that rims the Pacific Basin. Few segments of the ring suffer greater tectonic disturbances. In the area of last autumn's disasters, four crustal plates uneasily interact. Their movements caused the 1976 quake that killed 23,000 Guatemalans; they stoked the 1982 eruption of Mexico's El Chichón; they repeatedly trigger massive temblors along the Andes.

Neither disaster last fall could have been accurately predicted, given our present knowledge. But, as the following articles illustrate, much of the appalling loss of life could have been avoided, and much is being learned from these events. We know for certain that such disasters will strike again—and again—and that nations bordering the Ring of Fire must learn to detect their approach and better prepare for their assaults.

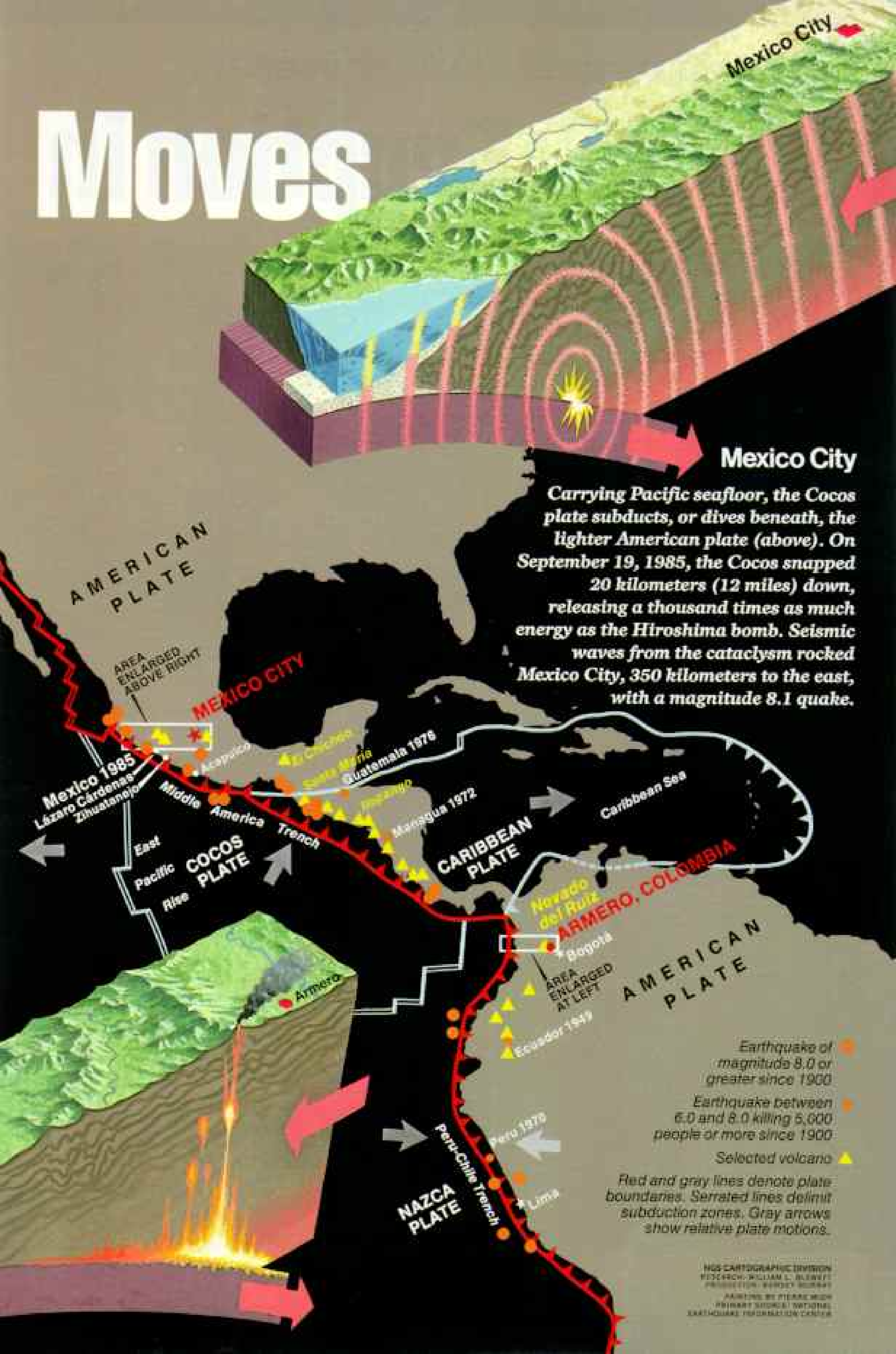
—THE EDITOR

Armero, Colombia

Head-on collision, the converging Nazca and American plates caused molten rock and gas to rise inside Colombia's Nevado del Ruiz (below) on November 13, 1985. Mudflows caused by partial melting of the volcano's glacier cap devastated nearby Armero. Ruiz, one of a chain of seven volcanoes, shows continuing signs of unrest.



Moves



Mexico City

Carrying Pacific seafloor, the Cocos plate subducts, or dives beneath, the lighter American plate (above). On September 19, 1985, the Cocos snapped 20 kilometers (12 miles) down, releasing a thousand times as much energy as the Hiroshima bomb. Seismic waves from the cataclysm rocked Mexico City, 350 kilometers to the east, with a magnitude 8.1 quake.

NGS CARTOGRAPHIC DIVISION
RESEARCH: WILLIAM L. ALLMAN
PRODUCTION: ROBERT MURRAY

PAINTING BY PIERRE MION
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23,000 villagers perish in volcanic mudflows

Eruption in

Colombia

By BART McDOWELL
ASSISTANT EDITOR

Photographs by STEVE RAYMER
NATIONAL GEOGRAPHIC PHOTOGRAPHER

CAROL GUZY, MIAMI HERALD/BLACK STAR

IT WAS LIKE an inquest to determine the cause of death. But the dead officially numbered 23,000.

In human cost this was among the greatest natural disasters in the history of South America—the cruelly ironic result of a minor geologic event: On November 13, 1985, Colombia's volcano Nevado del Ruiz had merely run a fever and cleared its throat. Now scientists, journalists, and officials were asking questions: What had really happened? Could the terrible loss of life have been avoided? How dangerous would this volcano be in the coming weeks and months? And how could future catastrophes be detected in advance?

From a U. S. Army Chinook helicopter, photographer Steve Raymer and I first saw the ruins. In the valley below us spread a fan of muddy debris. Here and there trees and rooftops protruded from the slime; a few islands of higher ground had collected a barricade of bizarre flotsam—smashed trucks, logs, boulders. It was hard to imagine that 23,000 people a few days earlier had prospered here in the "white city," Armero, famous for crops of rice and cotton and neat white warehouses for highland coffee.

Geologists use a Javanese word to describe a volcanic mudflow—lahar. Here heat from inside the mountain thawed snow and ice on a steep peak. Water churned down canyons and gullies, gathering mud, plant life, and wreckage on the way. This lahar had raced down the Lagunilla River

(Continued on page 646)

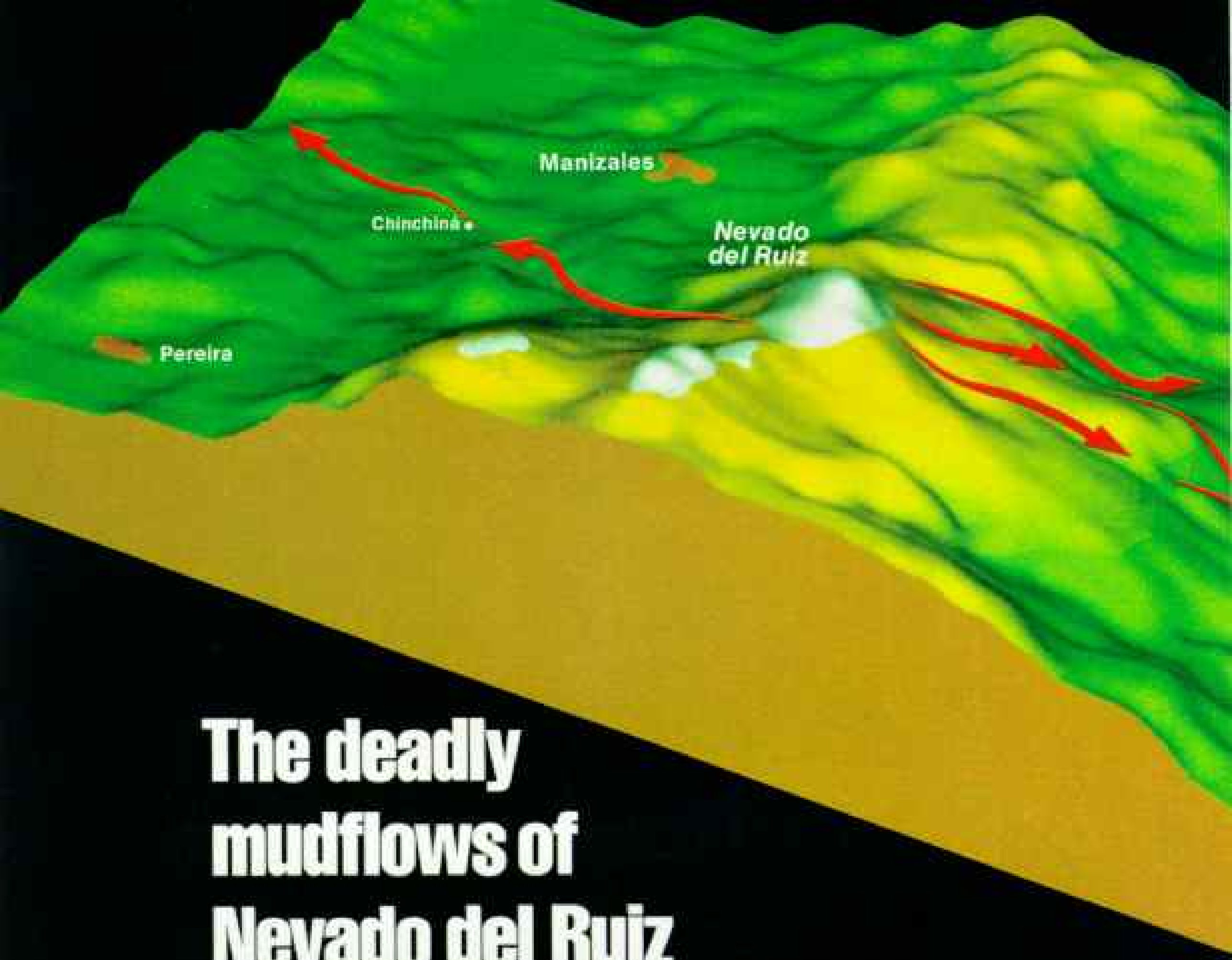
Mud and anguish mark the face of an injured woman rescued from the ruins of Armero. Some 20,000 died there when a torrent of mud poured down the Lagunilla River Valley to engulf the town.

Valley of death: Mud and debris litter what's left of Armero (above), once a busy agricultural center. Of its 23,000 residents, perhaps 3,000 survived. Two lobes of a mudflow, or lahar, swept away the buildings on either side of the high ground, leaving only these few structures. Some 3,000 died in other valleys.

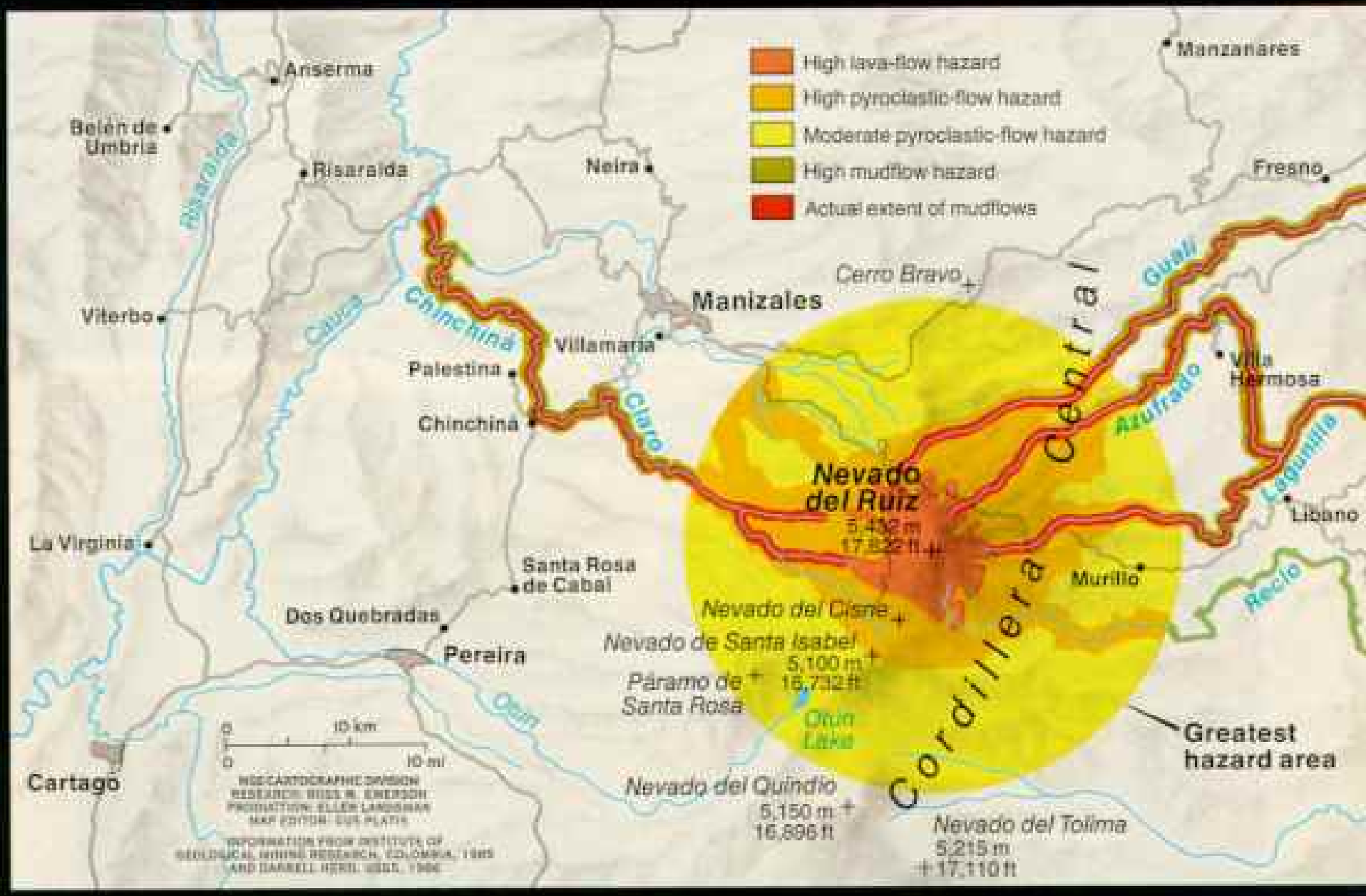
Located 50 kilometers (30 miles) from Nevado del Ruiz, Armero was a sitting target for a 40-meter-high (130-foot) wall of mud and ash that careered through the narrow canyon of the Lagunilla River, top, then spread over 40 square kilometers (16 square miles).

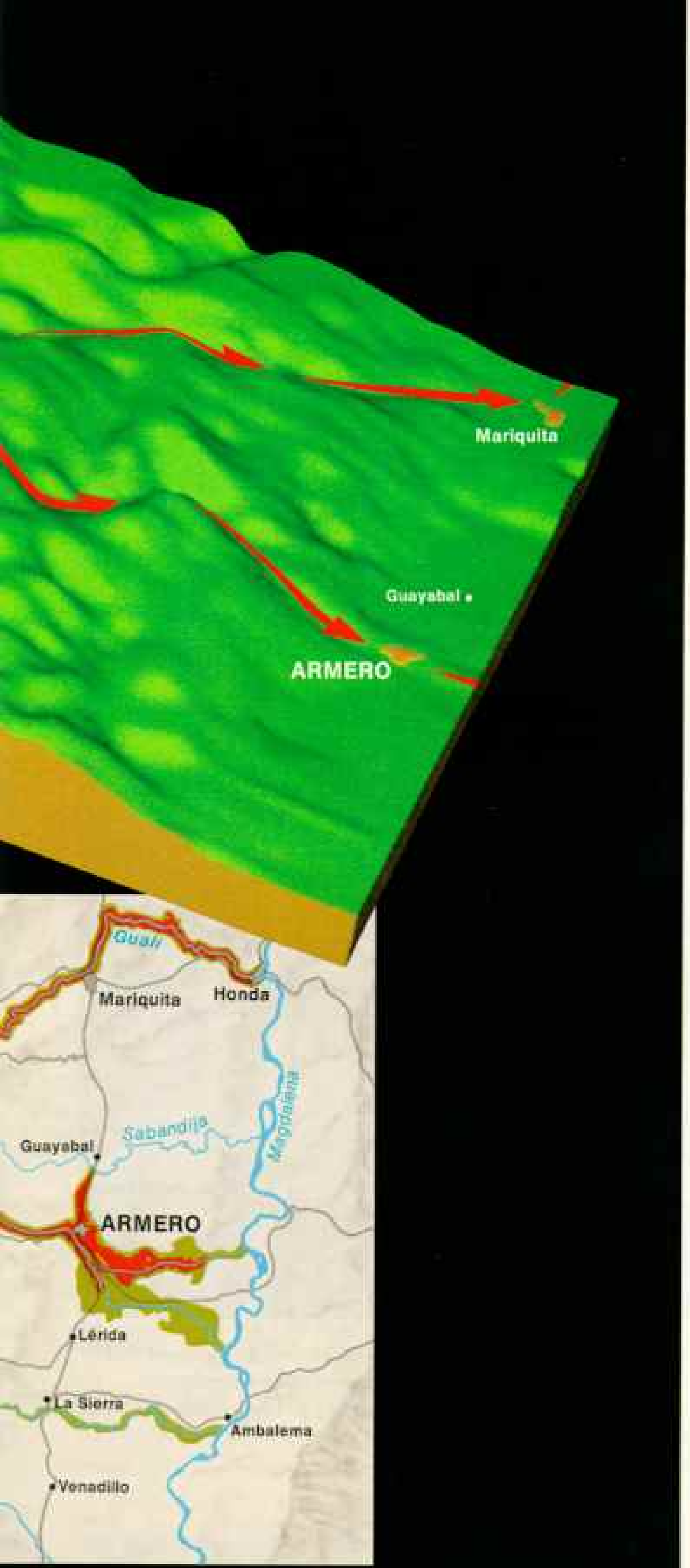
Striking just after 11 p.m., the lahar caught most people asleep. Nearly all who died were entombed in mud, often as deep as 3.5 meters. Frozen in his struggle to survive, a victim (right) seemed to be swimming in the deadly ooze.

ANTHONY SUAU, BLACK STAR (BELOW)



The deadly mudflows of Nevado del Ruiz





NEARLY FOUR centuries had passed since Nevado del Ruiz presented such an awesome display. Yet the November calamity—one of the largest human disasters in South America's history—did not come without warning. Earthquakes shook the area in late 1984, and minor expulsions of gas and ash occurred periodically throughout 1985 before the eruption and the resulting major mudflows (**left**, red arrows).

Ninety percent of Ruiz's ice cap remained unmelted after the disaster, and sporadic outbursts from the volcano caused panic and evacuations throughout the region.

The source of the unrest is a magma chamber of undetermined size below the volcano.

According to a hazard assessment prepared by Colombian geologists one month before the eruption (**map**), the area of greatest danger lies within a radius of roughly 20 kilometers of the Ruiz summit. Apparently only the immediate vicinity of the volcano would receive lava flows. But a broader area is subject to assaults by clouds of hot ash, gas, and rock. Called pyroclastic flow, this dense material may attain great speed. A small flow reached 160 kilometers an hour (100 mph) during the Armero disaster.

The geology of this segment of the Ring of Fire, a chain of volcanoes and earthquakes that circles the Pacific Ocean, is just beginning to be studied in detail. But with Colombia's capital of Bogotá lying within 130 kilometers of Ruiz, the government and scientific communities face the challenge of initiating a program of detection and prevention.

MELVIN PRUETT, LOS ALAMOS NATIONAL LABORATORY (TOP LEFT)

canyon on the eastern slopes, then spread itself wide, slowed, and come to rest heavily upon some 40 square kilometers (16 square miles)—one surreal and dunelike grave.

As our Chinook flew above the Lagunilla, we could see how the streambed aimed like a rifle, point-blank at the town. We could also see smaller mudflows—less destructive, because fewer people lived in their paths. In the town of Chinchiná on the western slope, a thousand people had died. But an air view gives little sense of the human scale.

HOURS LATER we visit the stricken valley by car and foot, following a flat highway with the sumptuous scenery of Hawaii—tasseling corn, herds of sleek zebu cattle, flowers in bloom.

In Mariquita we pause, so driver Alberto Bermúdez can inquire about relatives. His brother-in-law and his wife's mother and father survive—"*gracias a Dios*"—but sister and nephews have died in the deluge.

Soldiers at a checkpoint wave us on; now only pedestrians and rescue vehicles share our highway. In the half-deserted town of Guayabal, goats bleat and stroll across the street; women carry burdens of clothing and foodstuffs on their heads. "Emergency supplies," they tell us, pointing to the church that now serves as a warehouse. Inside, the stations of the cross are hidden by signs denoting rice, canned goods, beans.

We cross the small Sabandija River, where volunteers wait their turn for inoculation. We bare our arms for a student nurse to give us typhus shots ("already it is dangerous"), then move on, meeting a jeep, all of its passengers masked against the stench of death.

"Here were *fincas*, little orchards and gardens," says Alberto. "And *here*—Armero."

It is less a landscape than a world engulfed, a gray chaos of suffocating debris.

SHELLY KATZ, BLACK STAR (ABOVE); ANTHONY SUAU

Earthmovers aid the grim task of recovering the dead (above) for removal to a mass grave. Survivors were found as long as three weeks after the eruption. At a relief center in the village of Lérida (right), a young girl gets a dousing to remove mud. The failure to heed the volcano's warnings and order an evacuation touched off bitter accusations and recriminations.

"¡Vivan los gringos!" shout residents of Líbano (below), a village used as a receiving station for emergency aid. Dispatched from a U. S. Air Force base in Panama, Army Chinook helicopters (facing page) were among the first to arrive with food, medical supplies, blankets, and a scarce commodity: safe drinking water.

Beneath a tree we see a corpse on the surface of the mud. "Some people tried hanging on to trees," a rescue worker tells us, his voice muffled by a mask. Rigid hands still clutch for a phantom limb, a ghostly gesture of supplication.

Seven young Red Cross workers have gathered around the carcass of a cow. "We saw it breathe," a girl explains, "and poured Coca-Cola down its throat. Now look."

The animal, a zebu heifer, rolls bloodshot eyes. The youngsters tug, twist its tail, and the heifer reels up uncertainly on front hooves. We cheer—all of us—for this small victory of life. Within ten yards of the heifer, I count five human corpses, including the rigid man with pleading hands.

IT WAS MUCH LATER, after the horror had dulled us, that we could note the quality of the debris. It lacked kettles, the pits left by melted ice in a debris flow. This mud, neither cold nor hot, had not arrived with uniform force; many of the young trees had not been sheared away.

Many questions had to go unanswered in the ruins of Armero. To find survivors, we had to visit the tent city of refugees in Guayabal and talk to patients in the Mariquita hospital.

In excited Spanish, pretty 16-year-old Slaye Molina told us the story of her family. Ash began falling on the town at 5:30 p.m., "very soft, like sand," Slaye remembered it. An hour later a hard rain mingled with the falling ash and a "strong smell of sulfur."

But the public-address system at the church reassured people to stay calm. So did Radio Armero. Slaye and her family watched television and went to bed. "Then one of my uncles came and said, 'Get the truck! Move the whole family out!' But another uncle said, 'No—get hold of yourself!' And he went back to bed.

"At 11:05 the lights went out. I held matches to see my watch. And at 11:15 the mud came. Like a cloud.

"People screamed, 'The world is ending!' We ran upstairs to our terrace, but we saw another house collapse. So we rushed outside, though my grandmother had just had an operation and could not run. A friend took my hand and dragged me faster toward a hill. I looked back and saw my grandmother and aunt and uncle embracing each other. I do not want to be selfish, but I only thought about saving myself. I ran. The mud would catch up, and we would run faster. When we reached the hill, we saw Armero disappear in 15 minutes."

SLAYE SPENT three days on the hill, surrounded by debris, without food or water. When the mud hardened enough for her escape, she made her way to Guayabal, where she found her grandfather and a blind uncle still alive. She searched for others: "I cleaned mud from 29 bodies so I could recognize them, but none were my family. These are things of God."

The mud itself, arriving in the dark of night, held a horrible fascination for survivors. In the Mariquita hospital a young industrial worker named Efrén Torre Vergara remembered being caught by the flow: "It came in circles like batter in a blender. It turned me inside the mud, then brought me

out. I rode on top of the thing at very high speed, holding on to a car. And then it left me on the side of a hill."

A geologist later compared the mudflow to "a tumbler for polishing gemstones—about the consistency of mixed concrete." The acidic mud stripped leaves and bark off trees, clothes and skin off people. But the tumbling motion also swept people-size objects to the edges of the mud. Efrén's experience was typical of the lucky ones.

But the lucky were too few. María Alicia Muñoz Corredor watched her children "floating like corks and screaming" on the muddy surface. Twice she reached her baby "and touched her little hand, but the mud made her slip away." Driver Alberto Bermúdez knew an Armero man who lost both legs and one arm. "When he learned that all his family had been lost, he used his good hand to cut his throat."

I watched volunteers from a dozen countries working in the disaster area. Mexico sent a mobile surgical team just two months after Mexico's own earthquake. (See the article beginning on page 654.) A tired Mexican nurse told me, "Because we have also suffered, we want to help others."

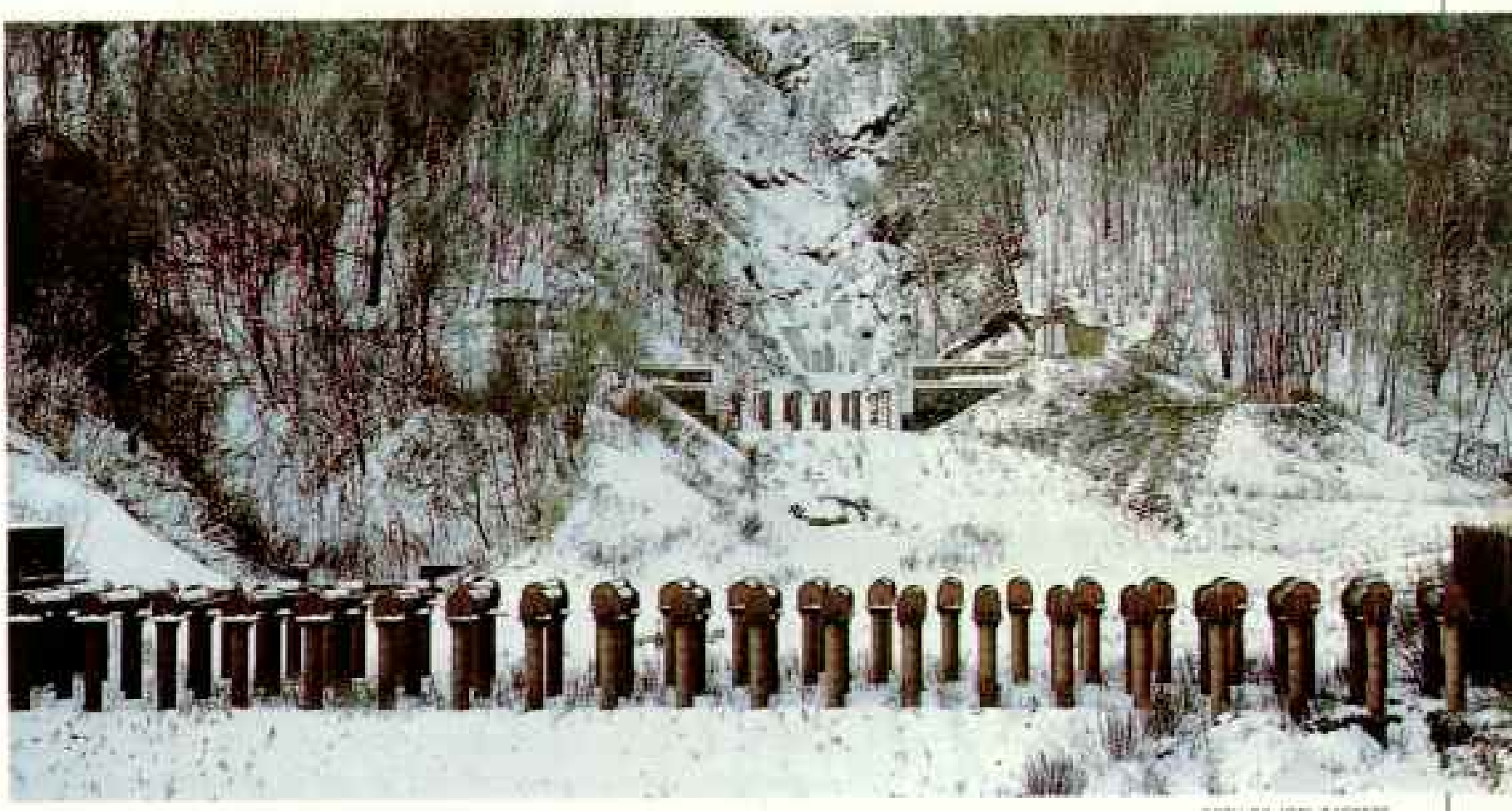
With special pride I joined U. S. Army helicopter crews taking loads of food and medicine to people cut off from the world. Days, even weeks, after our first sight of Armero, volunteers were still rescuing survivors.

IT WAS A RELIEF to join a team of geologists for their scientific inquest: scholars from Louisiana State University, the Universidad de Caldas, and Dartmouth College, and our National Geographic team. We would study the volcano itself, climbing into two vehicles with four-wheel drive, examining the material that Ruiz had recently expelled—solids, liquids, and gases. Their changing chemistry and quantity —as well as seismic readings taken by the U. S. Geological Survey and other scientists—would help show us whether magma

Japan keeps mudflows at bay

LIFE ON THE EDGE of disaster forges innovation in Japan, a Montana-size nation that harbors 10 percent of the world's active volcanoes. Japan is the world leader in mudflow control, technology not yet employed in South America. Steel and concrete slit dams on Hokkaido's Mount Usu (**below**) act as baffles to trap large boulders and retard the flow of mud generated by rain or volcanic activity.

Check dams obstruct the mudflow route on Mount Sakurajima (**right**), a consistently active volcano that has erupted more than 400 times in one year. Though heavy flows can spill over the dams, the structures buy time for evacuation of villages below and help keep small lahars from joining forces. Television monitors and sophisticated instruments that take 11 different measurements aid detection and research at an observatory on the mountain.



BOTH BY JOEL SACKETT

was moving upward. The balance of chlorine and sulfur is known to change before an eruption. We would also view the ice cap and note the course of lahars—past and potential—down the slopes.

We had no hard hats with us, and a pattern of harmonic tremor—continuous earth movement—and swarms of individual quakes suggested the volcano might spit pumice or lava anytime that day.

"If there's an eruption while we're here," our leader, Louisiana State's Dr. Stanley Williams, told us, "find shelter—maybe an overhanging rock. Or if you can't, look up. If a flying rock seems to get bigger, *move*."

While some of the scientists examined the terrain, others of us talked to ranchers and coffee growers who lived and worked on these slopes. They confirmed the chronology of that fatal day: Shortly after 3 p.m. "we heard an explosion and saw a column of ash"; a little past 9 p.m. "it was stronger and the earth shook—not like a tremor, but a rocking motion." "Yes, at 9 it arrived like vengeance, and we believed everything would be destroyed—finished!" "The stones began to fall, and it was also raining." "The stones were hot—some *this* big." (A farmer's hands showed us a pumpkin size.) "You can see holes in our roof—some people now have no roofs. And a few animals were injured. . . ."

Meantime, our party gathered specimens of pumice. "Not necessarily from *this* eruption," noted Dr. Williams. "Snow scrapers or shovels could have moved this material here." Later he found chunks of pumice embedded in the earth ("possibly hurled with great force") and still later: "You can see these pieces on top of the vegetation—and leaves are scorched." We could now be sure that these pieces had erupted recently. Chemical analysis would later show a remarkable similarity to the debris of the last major eruption, in 1595. Scientists could guess that this material had not recently come from deep within the Earth, but had just been part of the solid core of the volcano. Escaping gases, rather than a surging of magma, had blasted them from the crater.

From thermal springs of acid sulfate water near the top of Ruiz, the volcanologists measured temperature and gathered samples to compare with studies made years earlier. Increases in mercury and radon, for example, hold promise for predicting volcanic activity.

So could increasing emissions of sulfur dioxide into the air. Above us we could easily see the white plume of gases rising from fumaroles on the summit. Flying in a small plane, the team had already examined these gases with an instrument called COSPEC—correlation spectrometer—a remote sensor adapted from the study of air pollution.

We were also gathering volcanic ash, careful to collect specimens in spots protected from rain and untouched by human hands. "Not from the ground," Dartmouth's Dr. Richard Stoiber cautioned me. "Leaves are a good place to look—shake their ash into these plastic bottles." Samples would later be tested in a laboratory for sulfur and chlorine, which come from magma. A rising sulfur-to-chlorine ratio usually means that magma is also rising—a danger sign.

Each measurement added to our collection. So would the data used by Dr. Donald Lowe, LSU geologist and sedimentologist—a mudflow expert. He considers slopes, the curvature of riverbanks, and lahar deposits—and determines the velocity and depth of mudflows.

AS OUR VEHICLE climbed, the air grew cold and thin; rain turned to snow; and our road ended in a scar, slopes torn away by the flood. We had now reached an intersection of earth and sky where rocks and clouds resembled each other: igneous thunderheads.

We got out and clambered over the dark rocks. Then, standing beside a vertiginous waterfall just below the Ruiz summit, Don Lowe looked down and traced the course of one lahar. "We're seeing the evolution of a flow," he said. "Up here you don't find mud." The rocks, peeled of soil and vegetation, now were bare of all but grit. By the time two flows merged and gushed from the canyon three kilometers (two miles) from Armero, the lahar had become a watery mass 40 meters (130 feet) deep traveling 40 kilometers an hour. "And, of course," Don added, "they've had mudflows here before."

So they had. One was noted by the Book of Baptisms in the Mariquita church, dated 1845: "Stupendous and Deplorable

Happening, By the Holy Will of the Highest." The clergy described an earthquake-induced mudflow on the Lagunilla "so that . . . their successors, would not forget. . . ."

But people did forget such warnings. Quakes late in 1984 indicated a reawakening of Ruiz. By January 1985 more gases were escaping, and scientists reported recurring steam blasts. In July a cloud of yellow vapor was visible over the summit.

Scientists were not surprised when in September seismographs registered a new pattern of strong tremors. Fresh ash and lightweight lapilli were found on top of the snow, most likely from a major steam blast on the 11th. In October a young Armero resident wrote friends in California that Lagunilla River water was undrinkable because "the water of the river came down on us for three days with mud and sulfur."

In October, Ruiz seemed less restless; the venting of gas declined. But some Armero residents were still worried enough to leave home until officials reassured them.

Colombian scientists were now preparing maps of mudflow-hazard areas. Armero was clearly in the path. And on November 8 a warning was issued by the Colombian Institute of Geological Mining Research, INGEOMINAS, predicting a 67 percent chance that eruptions would cause mudflows, and noting that Armero could be evacuated in two hours without danger.

Volcanic tremor began on November 10 and continued for three days. On the 12th, people noticed a strong sulfur smell. And at 3 p.m. on the 13th, a technical emergency committee meeting in Ibagué, 70 kilometers from Armero, recommended the evacuation of Armero. There was then still time. Instead, Radio Armero urged calm and was still playing cheerful music when power failed and mud engulfed the station.

Scientific papers now warn that "a large volume of new magma and glacial ice make the volcano very dangerous. . . ." They urge "attention to Tolima volcano" nearby; in the past, action of the two volcanoes has sometimes coincided. An explosion like that of Mount St. Helens is always possible. And since some 90 percent of the glacier on Ruiz is still unmelted, they cite "an extremely high risk of future destructive flows."

Dr. Alfonso López Reina, director of INGEOMINAS, believes that Ruiz has a 50 percent chance of another eruption causing a mudflow like Armero's. Residents of Chinchiná would have just 39 minutes to flee.

Other geologists expand the list of endangered towns to include Guayabal and Honda. Even Manizales, which has 300,000 people, would suffer from ashfall.

And if Ruiz should blow its top? "Well, houses with weak roofs would cave in—ash is heavy stuff," notes Dr. Stoiber. "If the winds were from the west, the airport in Bogotá could close down because of ash." And Bogotá is 130 kilometers away.

If—and when? If gases continue to escape, the pressure inside Ruiz could diminish. As one geologist put it, "Then, we hope, we'll have flat champagne." The explosion might never come.

Never? Geology—like time itself—has no happy endings. Earth scientists need planetary patience as they watch and measure and predict a finite future. And all their warnings must conclude with *To be continued*. * * *

Chronology of a killer falls into place for an international team of scientists collecting ash and sediment (above). Thirty kilometers beyond Manizales (facing page) fumes continue to rise from Ruiz, whose eruptions helped create the rich soil of this coffee- and rice-growing area. In the aftermath of Armero, Colombia will remember how exacting this benefactor can be.

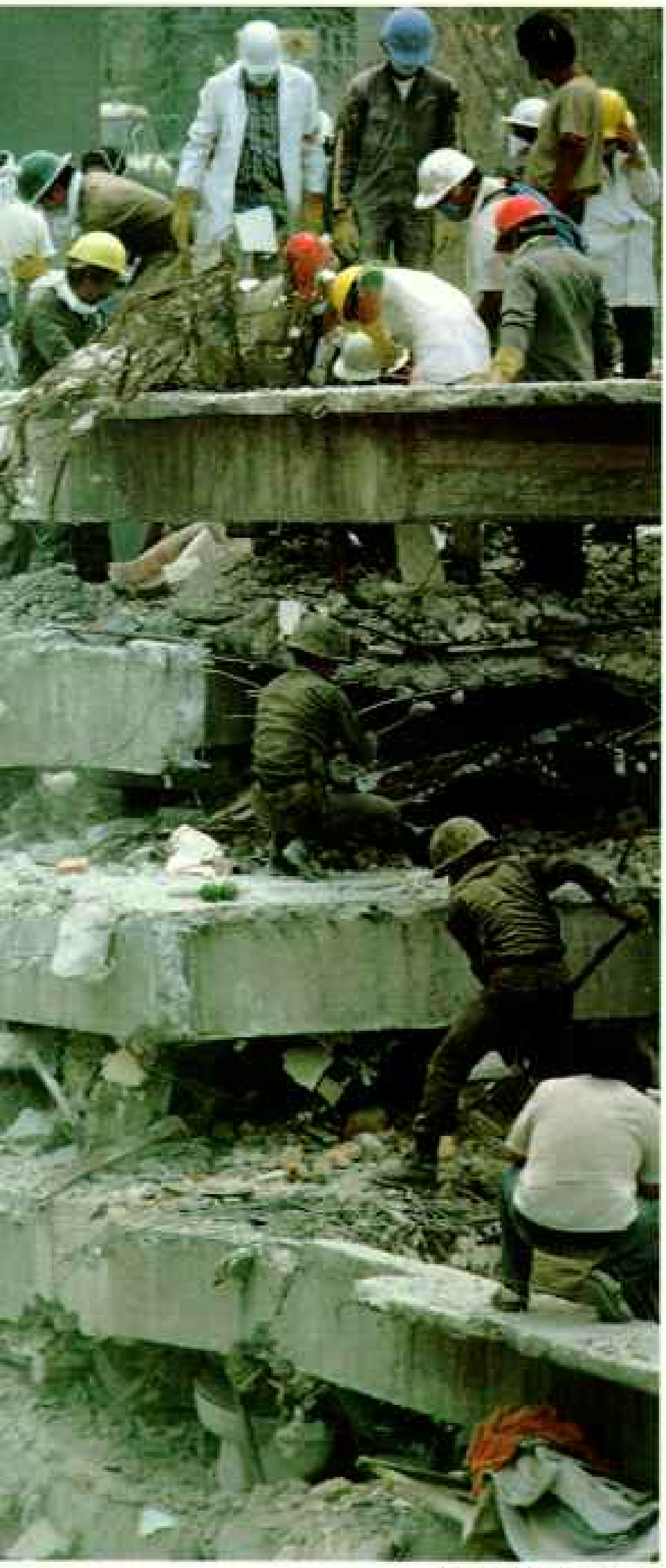
New clues to prediction, but are we prepared ?

Earthquake

in Mexico

By ALLEN A. BORAIKO
SENIOR EDITORIAL STAFF

Photographs by
JAMES L. STANFIELD
NATIONAL GEOGRAPHIC PHOTOGRAPHER
and GUILLERMO ALDANA E.



HERMAN J. KORDIAN, BLACK STAR

IN HIS THIRD-FLOOR office in downtown Mexico City, pathologist José Hernández Cabañas bent over his morning work last September 19. At 7:18 he felt the eight-story building begin to shudder beneath him.

Then the structure began to rock slowly back and forth in widening swings. Cabañas gripped a window frame. Looking out, he saw trees sway almost to the ground and thought, "This building can't hold up."

He lurched to a stairwell door but found it jammed shut. He smashed it open with his shoulder. On the quaking steps he slipped, fell, and tumbled downward, pitching helplessly from landing to landing. Passing the second floor, he heard people screaming to God for mercy.

Some 350 kilometers (220 miles) westward along Mexico's southwest Pacific coast, a giant slab of oceanic crust known as the Cocos plate had ruptured as it thrust beneath the continent's geologic foundation. Seismic waves a thousand times more powerful than the atomic bomb that leveled Hiroshima fanned out toward Mexico City, in pulses traveling 25,000 kilometers an hour (15,500 mph) and registering 8.1 on the Richter scale. So violent was the earthquake that tall buildings trembled in Texas, water sloshed in Colorado pools, and the entire Earth vibrated like a struck bell.

Cabañas landed hard near a ground-level exit door. A tremor shook it open and he started through, only to fall again as flying debris gashed his head. Covered with

Collapsing floor by floor, the Benito Juárez Hospital became a tomb for patients and medical staff alike on September 19, 1985, when Mexico City's most devastating quake killed more than 9,000 people.

blood, almost senseless, he crawled desperately into the street. At that instant his building toppled over backward.

When the shaking stopped, the battered and exhausted Cabañas grew terribly lonely. Almost all of the 18 million people in the world's most populous urban area, he thought, must certainly be badly hurt or dead, unable to aid or comfort him.

Schools, government bureaus, and office towers had collapsed upon themselves, or toppled, or been pounded to pieces by battering-ram blows from adjacent rocking buildings. Small shops lay crushed beside the stumps of taller neighbors that folded over upon them. Apartment buildings shorn of facades but still erect held tables and chairs and beds in miraculously undisturbed display, like grotesque dollhouse exhibits.

Here and there above the city, plumes of smoke began to rise black and dense through a fine haze of concrete dust. From leaking fuel tanks there wafted the sulfurous reek of gas. Broken mains and aqueducts cut off six million people from household water and hampered firemen. Electricity in much of the city was quenched when municipal generators shut down automatically; international telephone and telex lines were dead.

Outside demolished hotels, on sidewalks strewn with broken glass and brick, dumbfounded pedestrians wrapped their jackets around guests bedraggled in shredded pajamas and nightgowns. Two men scrabbled in the pulverized concrete of the Regis Hotel and freed engineer Danilo Cabrera; they cloaked him, naked but only lightly injured, in drapes from the smashed lobby.

Many hundreds lay buried at wrecked hospitals—healing places transformed into sepulchers. At the National Medical Center orderlies white-faced with plaster dust and tension bundled patients out of the warped Cardiology and General Hospitals, laid them on sidewalks—living here, dead there—and returned inside for others. Their grisly work was heaviest at a fallen dormitory for interns and in a monstrously crumpled maternity center. At the Benito Juárez Hospital the earthquake surprised a double complement of doctors and nurses changing work shifts; a crumbled main tower entombed a thousand patients and staff.

For many weeks after he recovered, the pathologist Cabañas worked 12-hour days to fill in for doctors who had perished.

"WHO KNOWS what we will find!" Weeping, filled with dread, a mother voiced the fear of everyone aboard our flight to Mexico City. She was going home, if she still had one; I came to see what had been spared of a great city and to report on efforts in Mexico and the U. S. to cope with future convulsions.

In the next days it became clear that, while Mexico City was seriously stricken, the vast majority of its buildings had ridden unscathed through the temblor and a 7.6 aftershock the next day. Fewer than 7,000 of the city's one million structures suffered damage or destruction. The baroque Metropolitan Cathedral and the austere National Palace still stood on the Zócalo, the city's main colonial plaza. The 52-story headquarters of Pemex, the state oil company,

National Geographic, May 1986

remained the tallest tower in Latin America.

Reconstruction costs—estimated at four billion dollars—have fallen painfully on a nation staggering under a 97-billion-dollar foreign debt. Even harder to bear has been the human cost of the cataclysm. More than 9,000 people—a precise count is impossible—died or disappeared in Mexico City. Possibly 30,000 more were injured, and at least 95,000 became homeless in a metropolis already acutely short of decent housing. Thousands more lost homes and hundreds their lives in other cities and towns.

By the havoc it wrought, the worst natural disaster in Mexican history drove home key lessons in predicting and preparing for earthquakes. It vividly confirmed a theory for forecasting quakes in "seismic gaps"—zones at the boundaries between jostling crustal plates where violent tremors are overdue. It yielded the best record yet of the terrifying bounce and roll of the ground in a mighty temblor—vital for understanding the genesis and timing of great quakes. It highlighted how cities on unfirm ground risk destruction even by a distant quake.

Most of all, Mexico's ordeal dramatized the need for earthquake preparedness. Despite a vaunted emergency plan, on civilian orders troops waited hours before deploying to keep order and direct rescue efforts; when finally mobilized, they sometimes barred volunteer brigades from rescuing trapped people. Cranes, jackhammers, concrete-cutting saws—all tools of urban search and rescue were tragically scarce.

HAD YOU BEEN ASLEEP on the beach at Acapulco as the earthquake struck 300 kilometers northward along the coast, you would have felt the sand no more than ripple beneath your back. But nearer the epicenter—the surface point directly above the initial fracture—

BOTH BY GUILLERMO ALDANA E.

Limp in death, the body of a child is retrieved from a condominium in the Colonia Roma section (above) of Mexico City, just 30 minutes after the first shock. Volunteers commandeered a nearby crane to extricate survivors from upper floors of the same building (facing page). The downtown area's foundation, a spongy lake bed built on since Aztec times, quivered like jelly during the quake, amplifying the seismic waves and exacerbating the damage.

When the quake hit, Danilo Cabrera (below) sprang from his bed in the Hotel Regis (right) and braced himself under the lintel of the bathroom doorway. The action saved his life. For tense seconds he listened to the crunch and crackle of steel and stone. In the next room a

DAVID WALTERS, MIAMI HERALD/BLACK STAR (BELOW); GUILLERMO ALGARA C.

woman's voice cried out, "¡Mamá!" Then the door frame and everything else fell, he says, "like an elevator."

Though he plummeted five floors, Cabrera suffered only cuts and broken ribs. Looking up, he saw that the door frame, shouldering a concrete slab, still sheltered him. Amid choking dust he said the "Our Father," then started shouting. Two rescuers helped him out. That evening (right) many other guests still lay buried in the rubble.

sleepers were catapulted from their beds.

At his resort beside the sea at Zihuatanejo, hotelkeeper Helmut Leins heard a deepening roar. Moments earlier the heaving Earth had spilled the Pacific from his beach; now an ocean swell called a tsunami was surging back to shore. Waist-high surf boiled inland (towering tidal waves are rare) and hammered catamarans and a ski boat into the front wall of Leins's hotel. In the deep ocean other seismic sea waves radiated toward Hawaii. Within eight hours they set Hilo Bay gently rolling, having raced 5,600 kilometers (3,500 miles) at jet-plane speed.

On their westward sweep the sea waves crested the mountainous East Pacific Rise, part of a chain of volcanic ridges encircling the Earth beneath its oceans. Magma in the ridges exudes through cracks in the old seabed, then cools and hardens into new crust. Earth's ever widening seafloors have clad it with tectonic plates—drifting slabs of crust that perpetually collide, tug apart, or grate by each other, causing almost all the million or more quakes that occur each year.

More than 25 million years ago the East Pacific Rise began to extrude the Cocos plate. This wedge of oceanic crust drives eastward four to nine centimeters a year against the American plate, which bears Mexico and the rest of the hemisphere west. Where the plates collide, the heavier Cocos

plate subducts, or dives underneath, the American slab and back into the Earth's interior along the Middle America Trench, an undersea crevasse 5,000 meters deep and 3,000 kilometers long.

Similar trenches rim nearly the entire Pacific, swallowing seafloor to be remelted. As magma, it stokes volcanoes—Mount St. Helens and Nevado del Ruiz among them—in a Ring of Fire arcing from New Zealand through Indonesia, Japan, and the Aleutians to the tip of South America.

This ring is also outlined by violent earthquakes, generated as slabs bend and buckle during subduction or rub side by side as along California's San Andreas Fault. As more is learned about how plates move, the earthquakes at their edges become easier to fathom and forecast. Indeed, geoscientists are growing increasingly skilled in anticipating earthquakes along plate boundaries where drastically bent rock has not broken as recently as in adjoining segments.

POINTING to such seismic gaps in Guerrero and Michoacán, Karen McNally, director of the Charles F. Richter Seismological Laboratory at the University of California, Santa Cruz, warned in 1981 that major quakes threatened Mexico's southwest coast. Like other seismologists McNally expected trouble—but where and when?

McNally conjectured that submarine peaks on the sinking Cocos plate had snagged the keel of the American slab and stuck fast. While the rest of the plate dived, the locked rock was bending under stupendous pressure long overdue to be unleashed. In May 1985 McNally, with geophysicist Victoria LeFevre of the California Institute of Technology, renewed her warning.

Mexico reverberates with five times as many big earthquakes as California. They recur more frequently too—about every 35 years. "You save decades of research into the life cycle of great quakes," says McNally, "by making a composite picture of Mexican tremors."

Last summer Mexican and U. S. scientists strung strong-motion seismographs like a trapline across the Michoacán and Guerrero gaps. When the September cataclysm burst from the Michoacán gap, the sensitive instruments captured an unsurpassed record of how the ground bobs and weaves near the source of a great quake.

These records show that the Cocos plate snapped 20 kilometers (12 miles) down and that rock lurched two meters eastward along a 200-kilometer front, in two wrenching jerks 26 seconds apart. This double kick disastrously extended the shaking felt in Mexico City.

Last year's quake was the fifth correctly foreseen in Mexico since 1978 with the aid of seismic gap theory. As with the others,

GUILLERMO ALDANA E. (FACING PAGE); HERMAN J. KOKOJAN

Waiting for word at the Benito Juárez Hospital, a father (above) carries a poster about his daughter, a nurse. At a stadium (facing page) serving as a morgue for thousands of bodies, dry ice is poured on a corpse. "It was shattering," says the author, "to see other coffins just two feet long."

however, the time and place where it would strike were too crudely signaled to prompt an earthquake watch or evacuation order.

More upheaval lies ahead on the Pacific fringe of southern Mexico and Guatemala. The Guerrero gap north of Acapulco alarms Karen McNally. Relatively calm since the turn of the century, and closer yet to Mexico City, it is by her projection the likeliest area for a future quake because "the longer since the last, the less time before the next."

"We'll suffer more great quakes," agrees Jorge Prince, head of the Mexican Society for Earthquake Engineering and an expert on quake-resistant building design. "They may even be more destructive. After what we've just seen, the prospect of another major quake shaking the unstable subsoil of downtown Mexico City is truly terrifying."

Sprawling across a valley two kilometers above sea level, and hemmed in by volcanic peaks, the city rests its core on the spongy clay of a much-shrunken lake, once a natural moat for the Aztec capital of Tenochtitlan. The Aztecs built where they saw an omen—an eagle with a writhing snake in its beak, perched on a cactus. When Hernán Cortés razed Tenochtitlan in 1521, symbolism likewise led him to found New Spain's capital in the same shallows. Largely drained in the centuries since, the lake left a veneer of mud atop deep layers of clay, sand, and gravel, all held in a bowl of bedrock.

From a handful of the old lake silt you may still wring most of its weight in water. Meanwhile pumping to slake Mexico City's thirst makes soil subside and buildings sink as much as 15 centimeters yearly. A teeming city upon a treacherous foundation in an earthquake-plagued land—"In a way," says Jorge Prince, "disaster *had* to come."

IT BRUSHED Norman Anaya as he walked to his car in Tlatelolco, Mexico City's largest public housing complex. Behind him the Nuevo León apartment block—15 stories, three wings, 400 units—began to seesaw. The thought of a dear cousin on the 12th floor so stunned the 21-year-old that his mind went blank.

Norman revived in his car, after unknowingly smashing into another, eight lanes across an avenue from where he had been parked. Still dizzy, he saw two wings of the swaying Nuevo León building collapse. Middle floors gave way; upper stories lost support and caved in one after another. People clawed wildly at lower windows as the slumping ruins heeled to the ground in billows of white dust that reminded Norman of snow. He found no trace of his cousin.

The devastation that confronted Norman had been vastly magnified by the unsure ground under his feet. Rock between the coast and the capital had absorbed most of the quake's short, sharp vibrations; what swept on was a series of long energy pulses, brutally powerful. Reaching the sediment-filled bowl below Mexico City, they were amplified and jolted the ground into motion for slightly more than three minutes—longer and harder than ever expected. At the height of the quake 20 seismic waves swelled at two-second intervals below the city, making its lake-bed foundation wobble like jelly.

Downtown, buildings began to sway in harmony with the rocking Earth, particularly those between seven and fifteen stories tall, which often have natural vibration frequencies of two seconds. Had ground vibrations died out quickly, destruction would have been minor. But as the rhythmic surge persisted, susceptible buildings swayed ever farther, their floors and walls cracking more and more with each swing until many finally pancaked, like the Nuevo León building.

"THE EAGLE that perched on a cactus here had a wicked sense of humor," Emilio Rosenblueth told me soon after the disaster. Now professor of earthquake engineering at the National Autonomous University in Mexico City, he helped design the 45-story Latin American Tower, still sound after the 1985 quake and a 7.9 quake in 1957, the last major quake to strike the city. In the interval, he told me, seismic safety provisions in the local building code were repeatedly tightened, but always on the basis of the 1957 shock—a release of energy one-half as great as occurred last September and not nearly so protracted.

"Building designs that otherwise would have been adequate proved unsafe," added Rosenblueth. "For example, on street corners you see the ruins of odd-shaped buildings, prone to twist on their foundations. In the case of many hotels and

business towers, columns in their open lobbies couldn't take the shaking that would otherwise have been absorbed in upper stories that were strengthened by the walls of rooms and offices."

Chastened engineers have again amended Mexico City's building code. It now decrees designs of greater stability and more exacting calculations of potential stress. New buildings must have room to sway without battering neighbors. Some street corners that saw collapses may not be built upon again and have sprouted flowers, grass, and park benches.

Negligence abetted the destruction. Before the quake the Nuevo León apartments and others in the Tlatelolco housing project had canted on ill-maintained foundations. The Juárez Hospital, damaged by a 1979 quake, allegedly collapsed because of poor repairs, certified as adequate at the time.

The earthquake did not fell all the city's death traps. Two mornings after the temblor I found a street in the garment district blocked by a crowd of dark-faced country girls, milling anxiously outside a cracked and teetering building. A lower floor showcased skirts, blouses, and dresses; five upper levels sagged with cloth cutters, presses, and bolts of fabric by the ton. "Upstairs at once," blustered a man, "or no work ever again!" Two girls mounted grim and shaky into the dilapidation and settled at sewing machines, aware that many similar sweatshops had collapsed, with garment workers often the last "property" to be rescued.

Day by day the litany of calamity lengthened. In Tepito, Mexico City's largest slum, I met Carlos Ortiz keeping listless watch in a smashed adobe tenement. A windowless, tomblike room had been home and workplace for the tortilla maker, his wife, and three children. Before the quake Ortiz had no lights or water. Now, he said, life was "a disaster on top of a disaster."

Even the dead had no respite. In the ashen dust of a potter's field I sidestepped scattered skulls and bones, hastily exhumed from hundreds of unmarked plots to accommodate those lately killed: a teenage girl, the aunt and uncle of a small, sobbing boy, two *desconocidos*—"unknown ones"—laid to rest on ice in a pine box now trickling water.

Gradually death's siege numbed the people of Mexico City and me with them. In a sports stadium serving as a morgue, people spoke little and wept less as they drifted like sleepwalkers among bodies blackening on ice. Ashamed that I was no longer moved, I turned away—and blundered upon coffins hardly larger than my own infant daughter. I gasped as if kicked in the stomach—but was relieved to feel strongly again.

Joyous resurrections, too, occurred. Four days old when entombed, a baby aptly named Jesús was the last of several dozen infants extricated alive from flattened

GUILLERMO ALDANA E.

Curbside cleanup in a tent city was the lot of many residents of Tlatelolco, a middle-class development that housed perhaps 100,000. A quake-damaged high rise towers in the background, one of a score or so of Tlatelolco dwellings that the government wants to raze.

The rise and fall of buildings - a primer for survival in quake city

DESIGN for disaster: As a quake rumbles through a metropolitan area, a kind of natural selection determines which buildings will survive. A structure whose long axis is parallel to ground motion **1** will sway less than another whose axis is perpendicular. Where such buildings are joined **2**, one wing sways more than the other, and a rupture occurs. Likewise, a tower rising from a lower structure **3** may fracture at the point of connection.

"Soft" supports, such as in a building whose first story is composed of only tall columns, can be the recipe for destruction **4**. Here both buildings sway the same amount, but A remains intact because it flexes as a unit. In building B, most flexing takes place in the soft first story, and the structure fails.

A building can resonate with the frequency of the ground waves, like a child on a swing being pushed higher and higher. The force applied at the bottom may be multiplied as many as five times at the top and result in destruction **5**.

Buildings close to one another that begin to sway may collide **6**, a phenomenon known as pounding. Because their masses are so great, even a slight touch can be disastrous.

In designing for survival in earthquake-prone areas, architects are paying more attention to local geology. Solid rock foundations **7** transmit seismic waves as short, sharp jolts. Uncompacted substrata **8**, such as the ancient lake bed under Mexico City, transmit rocking motions similar to those produced by an ocean swell. A building can be "tuned" so that it will not resonate with the ground wave and destroy itself.

Built on rock, a relatively tall building **9** has extra reinforcement at the joints where one structural member meets another. This construction allows strength with flexibility—under the stress of an earthquake the building will flex like a tree or an airplane wing. On soft ground a short, stiff building **10** will not resonate to long ground waves. Diagonal members brace the structure, adding rigidity.

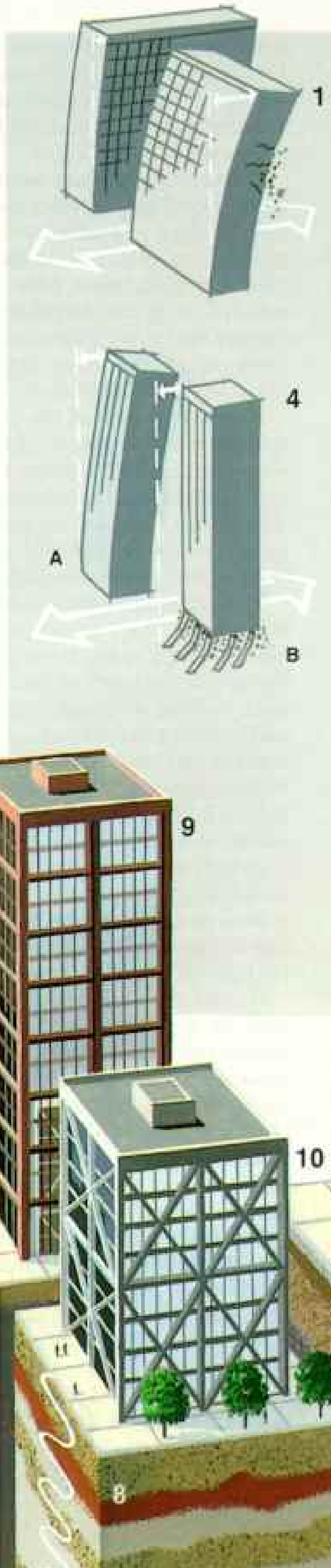
Even though a building **11** is strong enough to survive ground oscillations (arrows, lower right) of a quake, its innards could become a deadly shambles. On the top floor the unbraced ceiling panel carrying heating and cooling ducts collapses. A floor below, the sprinkler system ruptures, and the partition falls.

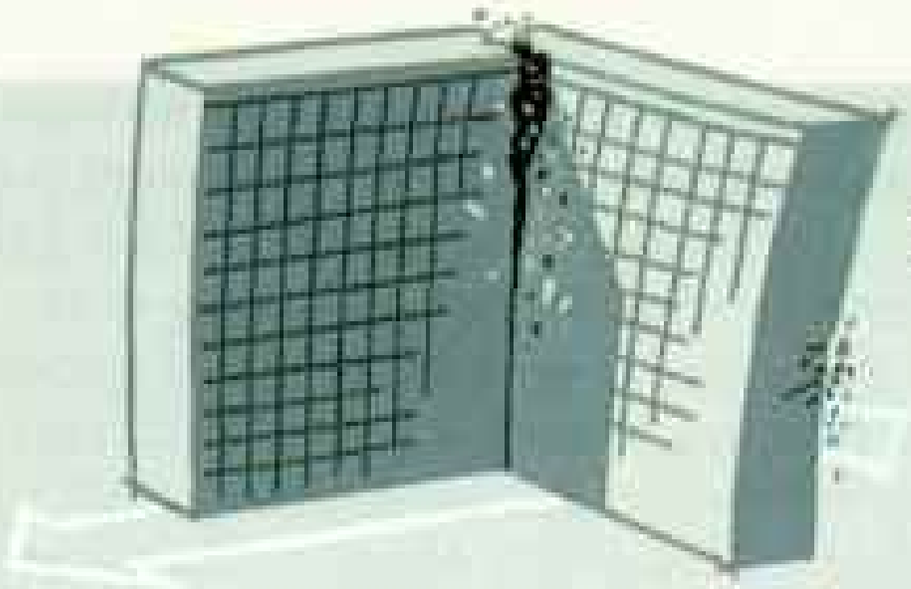
On the second floor unsecured banks of computers topple. Bookcases on the first floor fall like dominoes; a file cabinet reels with force enough to send a person flying. Distortions in the building may jam the doors, trapping people inside.

In the basement a huge gas-fired boiler and a generator are shorn from their cradles. Rolling like loose cannon, they tear gas lines and unleash the most feared secondary effect of a quake—fire.

Though the building codes in California and some other western states require quake-resistant construction, only a few communities—let alone states—east of the Rockies have adopted such codes.

PAINTING BY PIERRE MION





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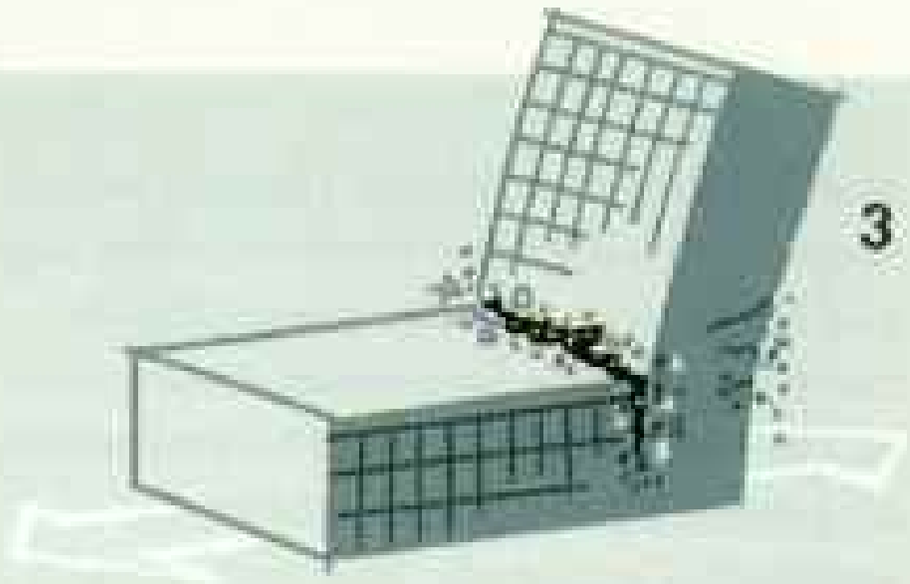

3

5

6


Hung ceiling with heating, cooling, and lighting fixtures
Sprinkler system
Unbraced partition
Computers
Bookshelves and file cabinets
Boiler, generator, and fuel lines

11

Rubber and steel plates (below) partly isolate a structure from a concrete slab shaking at earthquake frequency at the Earthquake Simulator Laboratory in Berkeley, California. The technique, employed in an office building in southern California (bottom), awaits the challenge of a major quake.

JAMES A. SUGAR, BLACK STAR (TOP); JAMES L. STANFIELD

hospitals in the first nine days after the quake. Some were found by camera probes or search dogs. The cries of others guided rescuers with electronic listening gear.

Jesús had dislocated hips and a dressing on his back when I saw him and other tiny survivors in an intensive-care unit at the Hospital Infantil de México. "They lived because they had good body weight at birth, and because newborns are physiologically prepared to get by for a time on internal stores of water and body fat," explained Dr. Dina Villanueva García. "How they fared psychologically we can only guess."

Among adults psychic pain was profound. "People call our hot line afraid that the quake was God's sign that they're doomed to hell," said psychologist María Blanca Moctezuma of the National Autonomous University. "Others suffer guilt because they live while friends are dead, or they pretend that missing relatives still survive. The only good in all this is that the quake affects too many people for anyone to feel singled out for punishment."

IF ANY PEOPLE have reason to feel singled out, it is Californians, most vulnerable of 80 million Americans living in U. S. earthquake zones.

A coastal slice of California—tapering from the Imperial Valley in the south to Cape Mendocino north of San Francisco—rides the Pacific plate northwest past the rest of the state, which lies on the American plate. The 1,200-kilometer-long San Andreas Fault and a skein of lesser fractures mark this cleavage and breed about 10,000 quakes a year. Few jiggle the ground so much as a passing truck, but with Mexico as a warning, Californians have renewed incentive to beware.

Along the heart of the San Andreas Fault, from Cholame to San Juan Bautista, the plates slip smoothly by each other at 3.5 centimeters annually, triggering no major quakes. But north and south of this region of "creep," plate edges are stalled—locked together by friction.

To recover lost travel time, rock west of the fault periodically lunges: by six meters (20 feet) near San Francisco in the 8.3 quake that mauled the city in 1906; by as much as nine meters in an 1857 convulsion,

200 kilometers north of Los Angeles.

Seismologists calculate that the northern San Andreas is strained enough again to batter San Francisco severely any day. And chances are that Los Angeles will bounce by the end of this century, if not sooner, in an upheaval to match the 1857 rupture.

If so, Californians will lose immeasurably more today than in those earlier shocks. If the 1906 quake hit anew in the San Francisco Bay area (which now holds 5.4 million people, seven times as many as in 1906) and at night, when most people are in their relatively safe homes, state officials foresee 3,000 people dead and 12,000 hospitalized. A rush-hour disaster would kill 11,000 and hospitalize 44,000. Night or day, airports, bridges over the bay, and most highways into San Francisco would be unusable, delaying outside aid for days.

In greater Los Angeles, a temblor equal to that of 1857 would kill 3,000 to 14,000 people and hospitalize 12,000 to 50,000. It would also halve electricity, sever two of three main water aqueducts, and block highways from the north with landslides.

"Don't forget fires," says Charles Scawthorn, a San Francisco specialist in urban seismic hazards. "They burned 28,000 buildings in the 1906 quake, making it still the costliest in our history. A similar quake today would destroy sprinklers, water lines, and fire stations, break gas mains, spill chemicals, short-circuit appliances, and make power lines arc. We face potential holocausts as serious as those seen in war."

Such threats would be tempered if the when and where of earthquakes could be exactly predicted. To that end researchers have sowed many of their sensors along the San Andreas Fault midway between Los Angeles and San Francisco. There, with one exception since 1857, moderate quakes have rattled ranches and the hamlet of Parkfield about every 22 years, most recently in 1966.

"There's a 95 percent chance that in 1988, plus or minus five years, Parkfield will be bucked again by a 6.0 quake," seismologist Bill Bakun told me. His estimate, ventured with his U. S. Geological Survey colleague Allan Lindh, qualifies as a model prediction because it specifies the probability, time, place, and magnitude of an expected quake.

Tapping a satellite image, Bakun pointed

Trying to decipher Earth's language, expressed in the squiggles of a seismograph, Dr. Karen McNally of the University of California, Santa Cruz, works to enhance the still uncertain art of earthquake prediction. She and her colleagues warned in 1981 and again last year that a major quake was due on Mexico's west coast.

JAMES L. STANFIELD

out the epicenters of past Parkfield quakes and aftershocks. "We know where to expect fault ruptures to begin and end, so we can deploy instruments in the best places to learn more about warning signs that might help us predict quakes reliably, anywhere."

One symptom under surveillance at Parkfield is the way in which shifting plates subtly warp the Earth's crust, an indirect gauge of accumulating strain. One night in a hilltop hut on the Pacific plate, I fired a laser across the San Andreas at a reflector five kilometers away, on the American plate. The beam bounced back with a tiny but brilliant magenta flare, instantaneously measuring a gap a fraction greater than the night before.

Other instruments at Parkfield register swarms of microshocks and record changes in the speed of seismic waves. Still others monitor the rise and fall of underground water and track the flexing of rock hundreds of meters deep. Fine wires stretched like sutures across the fault can sense its slightest creeping motion. All await an abnormal signal or ground movement—a precursor to herald an earthquake as gathering clouds betray a coming storm.

Scientists cannot always distinguish precursors from meaningless changes in the

Earth, so short-range predictions are not yet reliable. Moreover, while the most damaging U. S. quake of 1984—a 6.2 shock in California—occurred at the right place and with the right magnitude to fulfill a four-year-old forecast by Bill Bakun, it struck totally without warning.

In 1975 geophysical precursors gave mixed, long-range signals of a coming quake in northern China. Thousands of lives were saved when observations of odd animal behavior spurred Chinese scientists to sound a last-minute alert at just the right moment. At first U. S. seismologists were intrigued, hopeful that barking dogs, jittery chickens, and snakes abandoning their holes were peculiarly attuned to unknown earthquake precursors. But luck seems to have aided the Chinese as much as did animals.

"When pressed," Bill Bakun told me, "the Chinese admit that their animal data are questionable, or even worthless." U. S. scientists point out that the Chinese now give more weight to preparedness, because no matter how you make them, predictions don't prevent earthquakes.

THAT INESCAPABLE conclusion long ago forced itself upon disaster planners in Los Angeles. And since last September, this sister city of Mexico's battered capital relies even more on preparedness to safeguard lives and property amid Earth's inevitable convulsions.

"We treated Mexico's disaster like our own," says Shirley Mattingly, director of emergency management for the city of Los Angeles. "We sent a trainload of trucks, bulldozers, and cranes, both to help our neighbors and *(Continued on page 675)*

JAMES L. STANFIELD (ABOVE); NASA/KATIE POLEY, USGS/GIBSON STUDIO

Drop! During an earthquake drill, schoolchildren seek shelter (above) in Parkfield, California, rattled with a quake about every 22 years by the nearby San Andreas Fault. The red circle (right, center) locates the epicenter of the most recent quake, in 1966. The next is predicted for 1988, plus or minus a few years. Diagonal of yellow circles, whose size denotes magnitude, pinpoints quake epicenters along the fault. Circles at top right show aftershocks of the magnitude 6.5 Coalinga quake of 1983.

A wet Pacific wind caresses Daly City near San Francisco, but many of its 78,000 residents may be living on the brink. The San Andreas Fault slices through the edge of town, at top, heading offshore at Mussel Rock point, top right. During the magnitude 8.3 quake of 1906 that devastated San Francisco,

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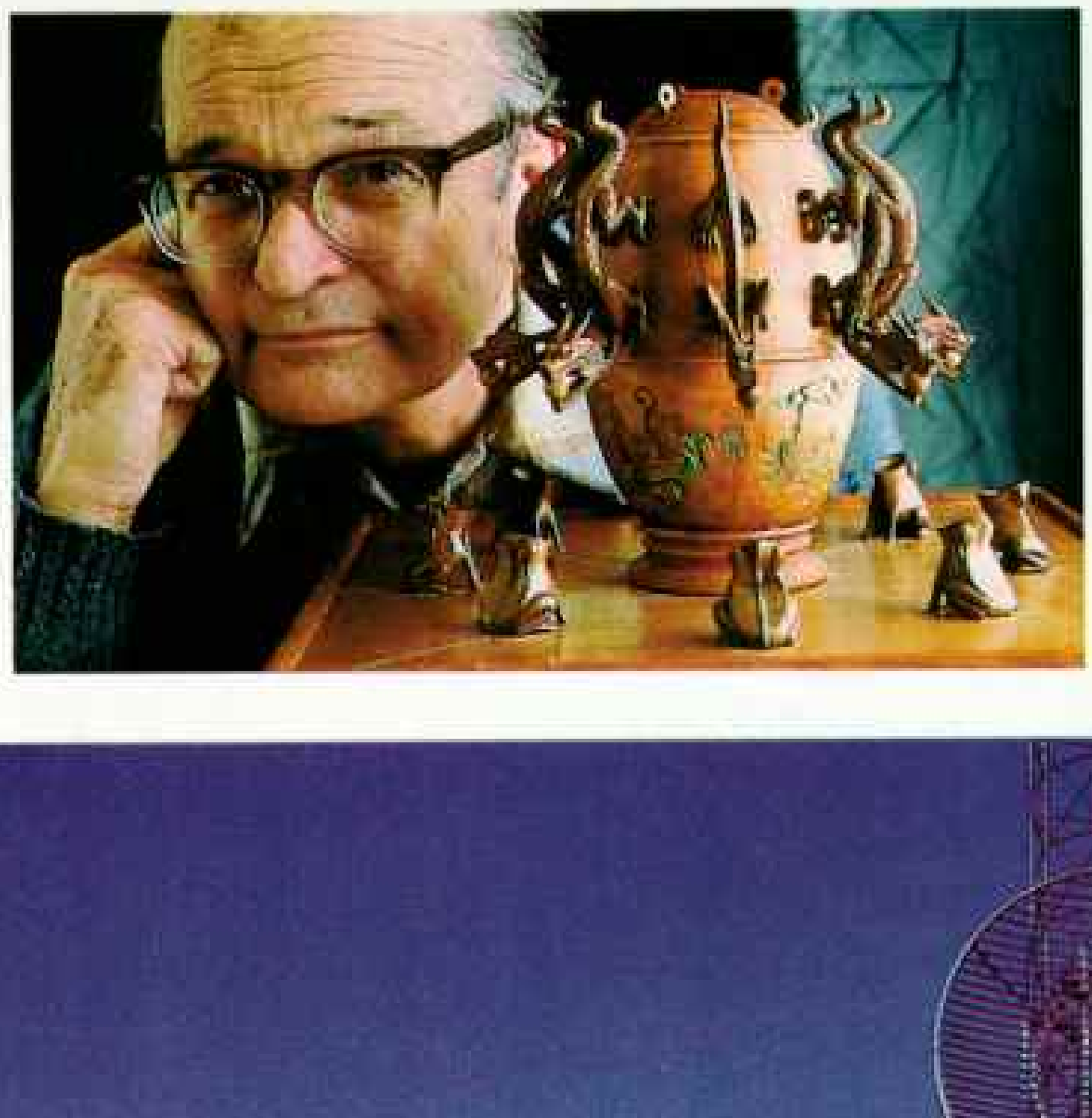
the fault ruptured here, and land to the south was suddenly displaced four meters. A 1957 shock triggered extensive slumping and landslides and damaged housing in the city. Storms have since gnawed the slopes, skewing subsoil and tilting foundations. Several homes have been abandoned.

Quake's waves would jolt a ball from a dragon's mouth (right), thought to reveal the earthquake's point of origin. The device, modeled after a second-century A.D. Chinese instrument, was presented to Dr. Bruce Bolt, professor of seismology at the University of California, Berkeley, by mainland Chinese colleagues.

Sandy Schulz, a physical science technician at the U. S.



Geological Survey in Menlo Park, demonstrates a 20th-century device—a creepmeter (right), whose wire is fixed to each side of a fault and can record horizontal movement.

A laser near Parkfield, flashed six times in this multiple exposure (below), bounces off distant reflectors to measure movement and subtle ground warping along the San Andreas.

ALL BY JAMES L. STANFIELD

to practice marshaling the equipment we'll need too one day. Always on our minds is that quake incubating on the southern San Andreas."

When it strikes, Los Angeles' nemesis will throw in gear an elaborate emergency response. One plan has inspection crews fan out to dams and aqueducts, hospitals and schools. Police helicopters whirl from a quake-resistant hangar. In an hour officials know roughly the extent of local destruction. A field hospital goes up at Los Angeles International Airport; planes ferry medical supplies in and patients out. Truck convoys roll from distant supermarket warehouses, bound for food distribution centers.

"We won't entirely achieve that planned scenario," concedes Mattingly. "We have tremendous resources, but realistically we expect to be overwhelmed. Most people will have to help themselves in the first three to five days after a quake."

Annually Los Angeles distributes millions of leaflets, urging residents to stockpile food and water and to have batteries, portable radios, and flashlights ready. Telephone books advise how to close gas cutoff valves to prevent home fires. A "quaky-shaky van" familiarizes schoolchild passengers with the sound and shudder of a real earthquake.

Throughout Los Angeles 8,000 aging masonry buildings are being reinforced. "In a quake you'd probably be safer here than in the street," said a city inspector as we watched workmen in an old store bolster brick with steel. Nearby, in a cafeteria with rustic motif, diners ate amid tree-trunk-size quake braces disguised by redwood bark.

WHAT of earthquake preparedness elsewhere in California? Quake bracing is required in the state's bridge and road spans and public schools, but not in some state university buildings nor in private schools attended by more than 500,000 children. San Francisco inventories 10,000 unsafe old buildings yet to be shored up; a curb on masonry parapets and architectural ornaments that could fall goes largely unenforced, leaving danger overhead. Statewide, people turn out annually for first-aid and evacuation drills to commemorate the anniversary of San Francisco's destruction on April 18, 1906. Unwittingly this reinforces public preoccupation with the San Andreas Fault, diverting attention from the fearsome potential of a smaller quake on other faults such as the Newport-Inglewood directly under Los Angeles.

As for the rest of the nation, "Seismic hazards are not generally recognized, and east of the Mississippi River earthquake provisions in building codes are almost nonexistent," says Otto Nuttli, professor of geophysics at St. Louis University.

Yet the farthest reaching rumbles ever felt in North America burst from a mid-plate fracture at New Madrid, Missouri, in 1811 and 1812. Staggeringly powerful, they tolled bells in Washington, D. C., and sent the Mississippi River raging over its banks.

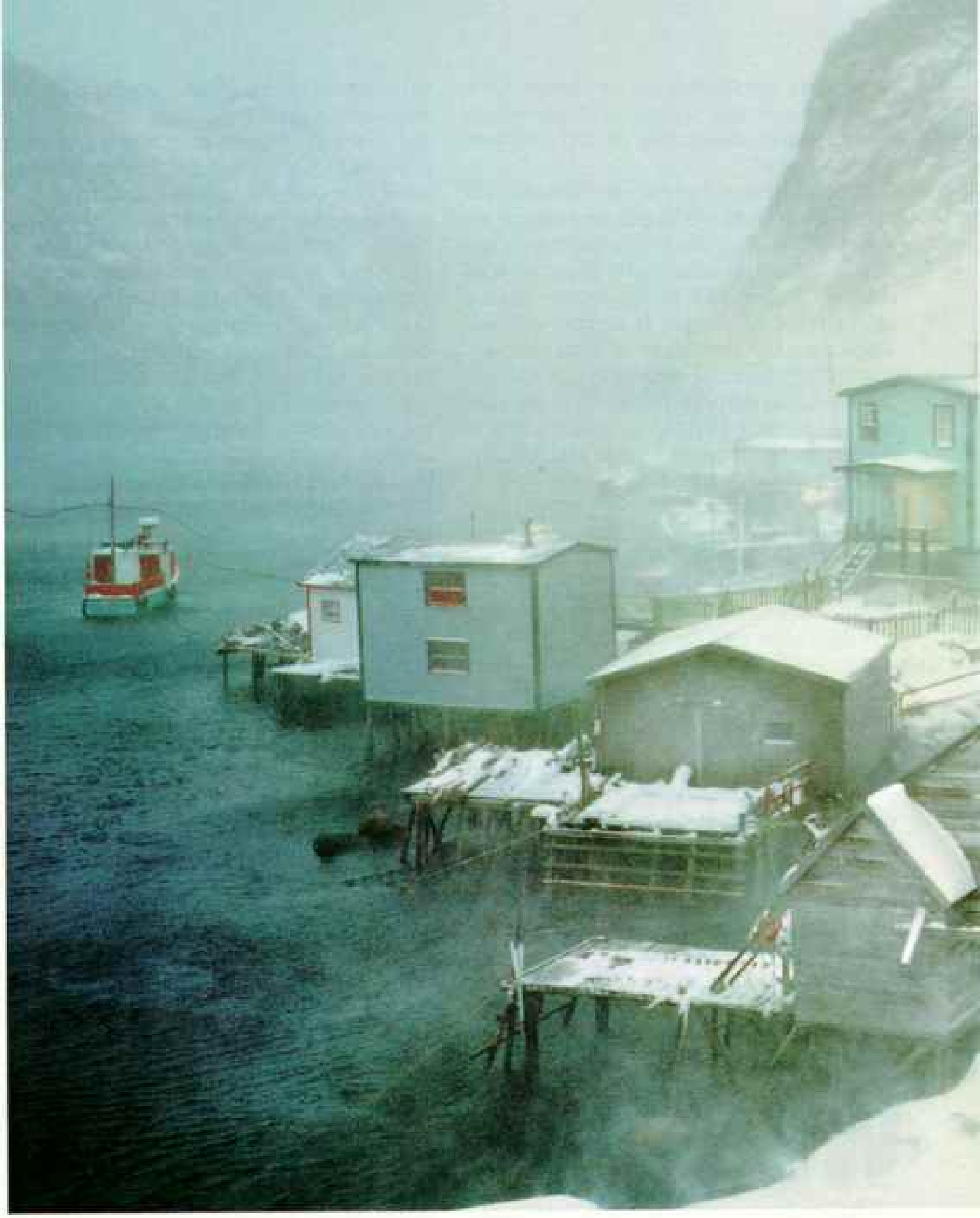
Massive earthquakes are unlikely anytime soon at New Madrid, where they recur perhaps once every millennium. But chances are good for a moderately severe quake in the next 15 years, and Nuttli warns that the geology of the East gives quakes there the same power of long-distance shaking as seen in Mexico.

Bruce Bolt, chairman of the California Seismic Safety Commission, reckons that in the past 500 years three million people have died in major quakes. Japanese myth lays these convulsions to the thrashing of a huge catfish. But a great stone, hefted by a god, can pin it down and still its flopping.

"We're improving our ability to predict earthquakes," Bolt says, "but we can never rely solely on forecasts to save lives. It's just as important to know how the ground and buildings will behave in a great shake and to prepare accordingly. After Mexico, we have a much better chance to hold down the earthquake demon." □

Twisted tracks at Lázaro Cárdenas on Mexico's Pacific coast attest an earthquake's ground-wrenching power. A tsunami caused by the quake deposited debris on the tracks. Though scientists increasingly understand the mechanics of quakes, the answers to fundamental questions remain elusive: Where? How big? And most important, when?

GUILLERMO ALDANA E.



NEWFOUNDLAND

The Enduring Rock

By HARRY THURSTON Photographs by

Stormbound by high seas and blowing snow, villagers in the outport of François head for cover on the south coast of the island of Newfoundland. Canada's oldest English settlement, it makes up, with Labrador, the nation's newest province—a hard place that has bred tough people.

YVA MOMATIUK and JOHN EASTCOTT

WEATHERED bald mountains rose from the edge of the sea as the wake of our swift little boat drew a wrinkle across the glassy waters of Belle Bay on Newfoundland's southern coast. Beside me at the rail, a young tourist from West Germany drank in the bleak beauty and the deep silence of the scene. "The north!" she exclaimed. "It's like the beginning of the world!"

How perfectly this youthful stranger understood "the Rock," as Newfoundlanders affectionately call their island. Battered by the Atlantic Ocean at Canada's easternmost point, it is an elemental place, open to harsh weather, infertile, remote, and watery.

Newfoundland's people revere their land for what it is. "We had no fields. We loved every rock in the place, but they were rocks. Our fields were the sea," William Marshall, Newfoundland's minister of energy, told me in the capital, St. John's.

Old Newfoundland was entirely of the sea. All its towns except St. John's, the main port, were called outports, wedded to the North Atlantic. Permanent settlement was fiercely discouraged until the early 19th century by piracy, fish merchant monopolies,

and international rivalries. When seasonal fishermen finally did put down roots, their reasons had little or nothing to do with the land. Isolated outport inhabitants turned their backs to the ungiving soil and trackless interior and their faces to the Grand Banks, the greatest cod-fishing ground on earth.

For nearly all of its four centuries Newfoundland's reason for being has been fish. John Cabot is believed to have reached its shore in 1497, nearly 500 years after the Vikings and at least 4,400 years behind the Indians. He found the sea "swarming with fish, which can be taken not only with the net, but in baskets let down with a stone." News of this finny treasure electrified Europe. By August 3, 1583, when Sir Humphrey Gilbert slipped into St. John's harbor to claim Cabot's newfound land for England, fishermen from Europe had long been harvesting the cod. Basques and Portuguese may have arrived before 1500.

In the 18th century sovereignty was disputed by Britain and France. Fishing rights were always the heart of the matter in controversies that continued into the 20th century. Rejecting union with Canada, the people of Newfoundland governed themselves as a dominion under the British crown from 1832 until 1933, when in the depths of the Great Depression, with the fishery in ruins, local rule was withdrawn by London. For the next 15 years Newfoundlanders' affairs were conducted by a government commission comprised of British and Newfoundland appointees. Not until 1949 did Newfoundland and Labrador become Canada's tenth province. And 35 years afterward I was introduced by one elderly Newfoundlander as "the gentleman from the Dominion of Canada."

Ninety-five percent of the province's 581,000 people trace their ancestry to Britain. It is Canada's poorest province, with the lowest per capita income, $9,700 Canadian ($6,700 U. S.)—two-thirds of the national average—and the highest unemployment, a demoralizing 21.9 percent.

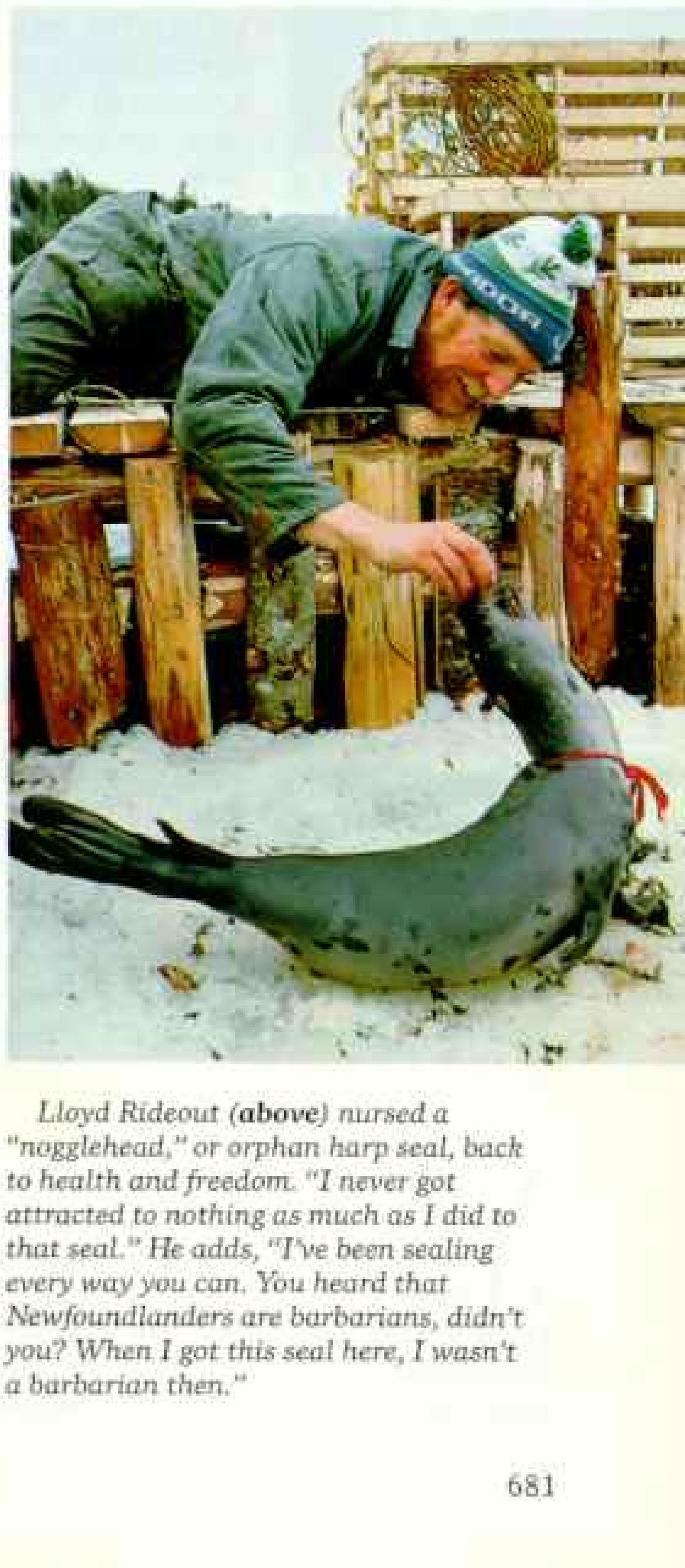
In the past decade the government has pursued an economic policy based on the traditional renewable resources of fisheries, forestry, and hydroelectric power, with the aim of molding a dynamic rural society. This back-to-the-roots policy is close to the heart of Newfoundland's 43-year-old

Author **Harry Thurston**, poet and journalist, lives in West Brook, Nova Scotia. **Yva Momatiuk** and her husband, **John Eastcott**, are frequent contributors to NATIONAL GEOGRAPHIC.

Neighbors masquerade *in François and go "mummering" at Christmastime, a revel from medieval England with roots in ancient Rome. When mummers enter a house, the family within tries to provoke them into revealing their identities. Discovered or not, they are rewarded with food and drink.*

The sea, always the sea, *has been Newfoundland's provider from earliest times. Inshore netting of codfish (**below left**) persists near Twillingate—an outport on an out island that once traded directly with England. Larger vessels fish far offshore.*

*If cod-liver oil was once a panacea, so offshore oil and gas hold out hope of a tonic for Newfoundland's sickly economy. Yet problems are fearsome. A workboat (**left,** foreground) strains in an attempt to tow an iceberg away from a drill ship, background, off the Labrador coast. Despite huge projected reserves, no wells are yet in commercial operation.*



*Lloyd Rideout (**above**) nursed a "nogglehead," or orphan harp seal, back to health and freedom. "I never got attracted to nothing as much as I did to that seal." He adds, "I've been sealing every way you can. You heard that Newfoundlanders are barbarians, didn't you? When I got this seal here, I wasn't a barbarian then."*

premier, Brian Peckford. Himself a rural Newfoundlander, Peckford has a mainland reputation as a political scrapper. This embarrasses some Newfoundlanders and pleases others. "Brian do stand up for Newfoundland," an outport woman allowed.

Premier Peckford, though he sometimes is described as a rural romantic, does not advocate a return to the profound isolation and the poverty of the past. Rather, he told me, he envisages a Newfoundland with the best of both worlds: modern amenities and rural values. "That's my kind of society," he declared, "because of its values, because of its closeness, because of its lack of man-made complexity."

With the Union Jack, *Nellie Carter comments on a July 1 celebration of Canada Day. Loyalties dating from the time of Elizabeth I are not readily shed.*

Today most fish (cod now accounts for less than half of total fish landings) is frozen for the United States market. Mining products, principally iron ore from western Labrador, outstrip the export value of fish. And offshore oil, discovered in 1979, is having an impact on the Newfoundland economy as oil firms gear up for production in the 1990s. But the fishery remains the largest resource-sector employer, providing full-time work to 20,000 fishermen and fish-plant employees, and to nearly as many again on a part-time basis.

NEVERTHELESS, wherever I went along the deeply indented 6,500-mile landwash of the island of Newfoundland, a dispiriting pall of uncertainty clung to the coast like fog. The fishery, residents told me, was in trouble again. Big offshore fishing companies faced bankruptcy and could do nothing, it seemed, but wait for a federal government bailout while their costly deep-sea trawlers rusted at dockside. The bailout, when it came, created one of the world's largest fish companies, Fishery Products International, but did not solve overnight the industry's chronic ills.

Despite high hopes of prosperity that were raised when Canada declared a 200-mile limit for its territorial waters in 1977, small-boat fishermen's yearly incomes have remained low—$7,000 to $10,500 Canadian ($5,000 to $7,500 U. S.) by government accounts. Bill Short, of the Newfoundland Fishermen, Food and Allied Workers Union, put it lower: "The small-boat fisherman who takes home more than $4,000 [$2,900 U. S.] is a rare species in Newfoundland."

To make matters worse, the traditional hunt for harp seals has been beleaguered by international protest, further endangering the tenuous livelihood of 5,000 to 6,000 Newfoundland fishermen. On Twillingate Island, in Notre Dame Bay, the stark white steeple of St. Peter's Anglican Church rises from the leaden land. In 1862 parishioners had purchased a tower bell "in grateful appreciation of the bountiful seal harvest." The descendants of those sealers have less to be thankful for: The European Economic Community has supported a ban on whitecoat (harp seal pup) products, sounding a knell for the industry.

"Old boy, the people just don't understand," Jack Troake lamented when I asked him about critics of the seal hunt. Troake explained that he needs the $5,000 he can earn sealing in order to buy equipment for the spring and summer fisheries. Without that working capital (one-third of his annual income) his entire year's operation is jeopardized—and so is the livelihood of the 30 people in Twillingate who, one way or other, depend on him.

Troake, 48, is a so-called landsman, like the other 700 Twillingate sealers. He works from his fishing boat a few miles from home port and takes mature seals, rather than the white-furred seal pups that are found on ice floes farther offshore and, until recent years, were harvested from factory ships. "No sir, they don't understand," Troake repeated. "We depend on the seal hunt."

Nowhere is the dilemma of disadvantage,

Newfoundland

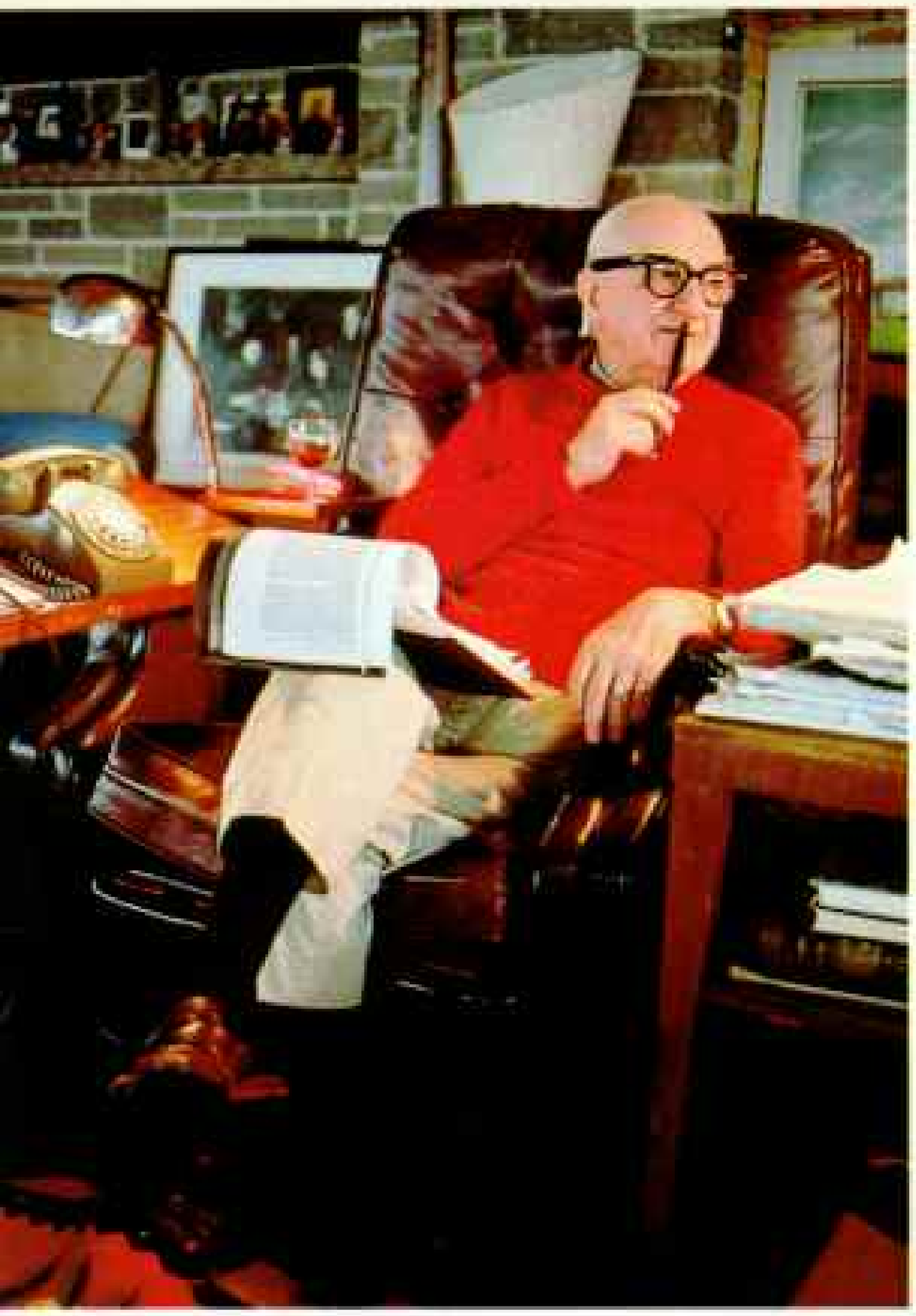
AFTER THE ICE AGE ended 10,000 years ago, successive bands of Indians and Inuit moved across mainland and island. Vikings settled briefly at L'Anse aux Meadows about A.D. 1000. John Cabot sighted the coast in 1497, and when Sir Humphrey Gilbert claimed it for England in 1583, St. John's harbor was already full of English, French, Portuguese, and Spanish fishing boats. Though rich in resources, the province's economy is chronically depressed. Work is seasonal; unemployment hovers at 22 percent.

AREA: 156,650 sq mi (405,720 sq km). **POPULATION:** 581,000. **CLIMATE:** Ranges from arctic to maritime. **ECONOMY:** Manufacturing (fish products, pulp and paper), construction, mining, electric power.

Midwinter fast ice (forms and remains along coast)

Midwinter sea-ice limit (50% to 100% coverage)

Soundings in meters



Mastermind of confederation *with Canada in 1949, Joseph R. "Joey" Smallwood* ***(left)*** *served as provincial premier from 1949 through 1971. Among his controversial policies was relocation to larger settlements of residents from such outports as now empty Parsons Harbour* ***(right)****. Though removals were voluntary, some residents claim to have been misled into leaving.*

and the change that worsens it, more dramatic than in the isolated outports along Newfoundland's south coast, one of the last areas still largely inaccessible by road. One of the outports, François, is situated halfway along the coast, at the bottom of a bowl carved out by a glacier. Lowering hills, sheared off at the top, form a landlocked semicircle around the harbor. A rockslide, frozen in a geologic moment, seems poised to crush the fragile houses—turquoise, dory yellow, bright green—that are cradled between the wind-scoured land and the wind-tossed sea (pages 676-7).

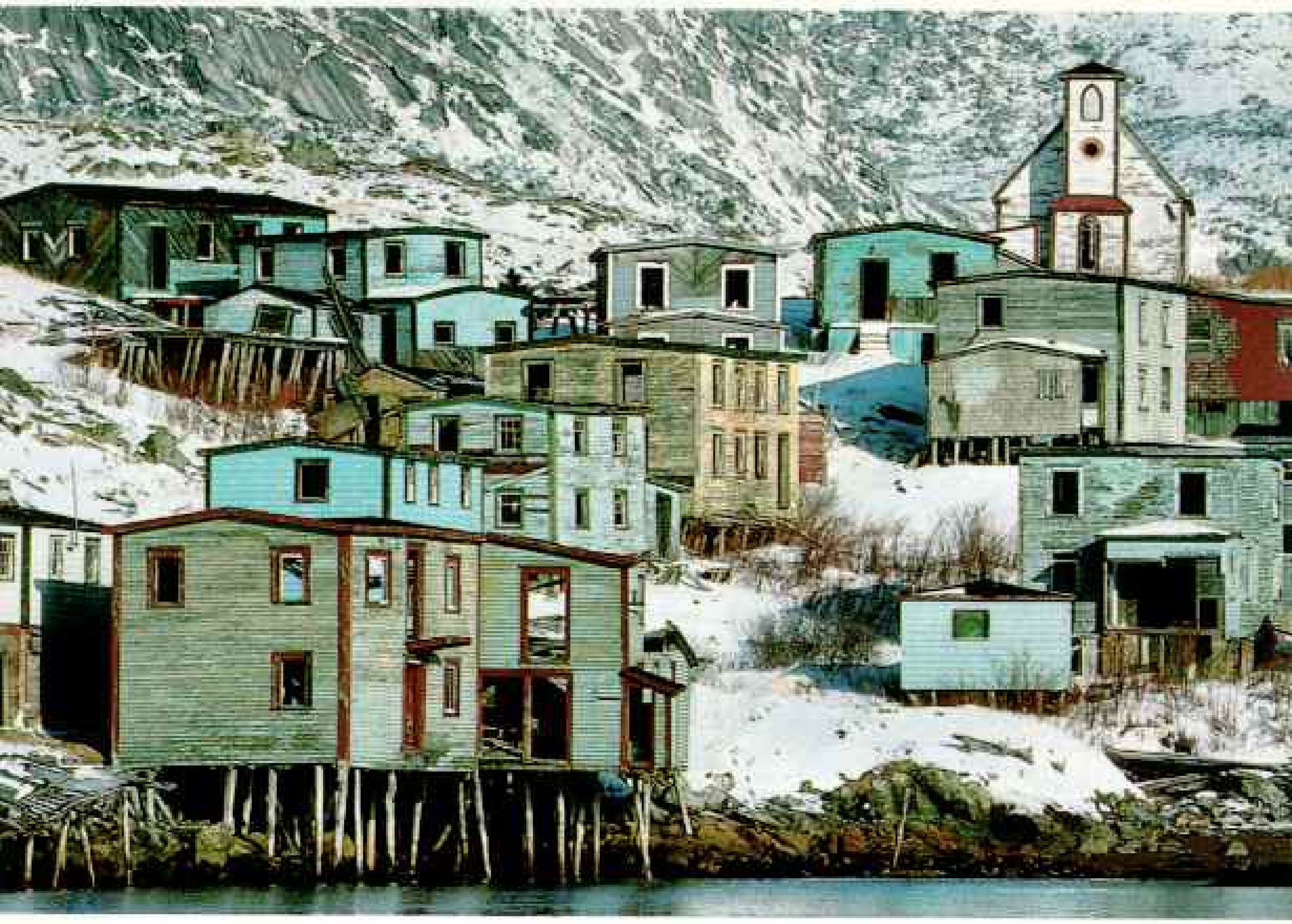
François's television antennas—makeshift wooden crosses, unnervingly like primitive grave markers—are silhouetted on the hilltops. I heard it said more than once in the outports that the arrival of television had changed Newfoundland irrevocably. However that may be, the music of outport kitchens, the ticking of clocks, the sputter of fireboxes, and the rhythm of knitting needles and rockers now must compete with the cacophony of the sitcom and the quiz show.

Next to his oil range, with a tobacco-can spittoon at his side on the polished linoleum floor, François's Uncle Bob Skinner rocked and contemplated the modern world. All older men are given the respectful title of "uncle" in the extended family of the Newfoundland village. "No square dances any more," Uncle Bob gently chided. "They only have the belly rubs, I call it. Nah, all changed. If our young people live long enough, I suppose, they'll be modern like the whole world."

NOT ALL YOUNG FOLKS want Newfoundland to change. "I'll never leave this place as long as I can make a living in fishing—I like fishing," 19-year-old George Durnford of François told me. If you live in an outport, one thing has not changed. You must fish—and that's a harder life than most will bear. George and his father clear from $150 to $500 each in a week of fishing from a small boat.

There is still no road into Petit Forte, another isolated outport tucked into the eastern shore of the Burin Peninsula, so I reserved space aboard the medical helicopter with Dr. Geoffrey Fowlow, who treats patients at the community clinic every two weeks. "I like to think about it as a way of doing my bit to maintain the traditional way of life in Newfoundland," explained Fowlow, a native Newfoundlander. We flew over the whale-backed islands that sprinkle Placentia Bay—Bar Haven Island, Sound Island, deserted communities with ghostly shells of houses looking blindly out to sea through broken windows.

In the 1950s and '60s the provincial and federal governments tried to depopulate hundreds of isolated outports such as these, on grounds that government could no longer



afford the cost of roads, electricity, schools, medical care, and other services. The treasury paid families an average of $2,300 ($1,600 U. S.) to move to "growth centres."

The inhabitants of nearly 200 outports did resettle, many of them happily. Electricity, running water, a better education for their children, and wage security were strong incentives. And fish prices were low.

But the people of Petit Forte stood fast, and today the community is undergoing a revitalization. Many Petit Forte young men have returned home from Labrador City or Great Lakes freighters or Nova Scotian trawlers to fish from small boats and see their families grow up as they did within the sheltering ring of familiar hills.

SUPERFICIALLY, the landscape of Newfoundland may seem lonely, primeval, almost untouched. But beneath the surface lie layers of history and culture. Maritime Archaic Indians arrived nearly 5,000 years ago to hunt seals, walruses, and seabirds. All these species are depicted in artifacts unearthed at burial grounds near the modern-day fishing center of Port au Choix on the Strait of Belle Isle. Around A. D. 1000 Vikings established a short-lived settlement near L'Anse aux Meadows, at the northernmost tip of Newfoundland's Northern Peninsula. Just across the strait, from about 1540 to 1610, Basques hunted right whales and bowhead whales from seasonal shore stations in southern Labrador.*

The first permanent European settlers put down roots in 1610 on the easternmost Avalon Peninsula. The population gradually spread along the coast, peopling those "precious rocks," as one man I met dubbed the islands and headlands.

"It's a rough old coast to make your living on," shouted fisheries officer Harvey Horwood, at the wheel of a fiberglass patrol boat that literally *(Continued on page 690)*

*See "16th-Century Basque Whalers in America," in the July 1985 NATIONAL GEOGRAPHIC.

Canada's easternmost city, *St. John's* ***(right)*** *is about as close to Ireland as it is to Winnipeg and has looked as much toward Europe as to North America. Provincial capital, port, and commercial center, it serves a metropolitan population of 160,700. Outbound ships sail the world's oceans, and helicopters service oil rigs on the Grand Banks.*

In colonial times Britain and France battled on Signal Hill, left foreground.

Near Cabot Tower Guglielmo Marconi received the first transatlantic "wireless" radio signal in 1901 from England.

Looking tickled pink, Deanne Sheppard ***(above)*** *from River of Ponds blooms as a flower girl.*

Concatenation of northern gannets *flocks to protected breeding grounds atop a sea stack at Cape St. Mary's. Emblematic of the Newfoundland*

oceanic tradition, these raucous, goose-size birds range far out into the North Atlantic and excel at fishing, plunging into the sea after their prey.

flew between wave crests. We pounded past trap skiffs, the traditional 25-foot Newfoundland inshore boats, as fishermen hand hauled gill nets from the loppy water of Notre Dame Bay on the northeast coast. In one small boat two young men in drab green slickers expertly freed the cod and turbot from the nylon mesh and flipped them into wooden boxes on the gently rocking deck. Mottled crabs clung tenaciously to the net as it was pulled from the water. The fishermen filled a five-gallon plastic pail with the delicious shellfish and made us a gift of them.

These small-boat fishermen venture only a few miles from port and return each nightfall. Their fishing incomes are among the lowest in Newfoundland. Some continue to fish in late summer—not because it pays to do so but because they need more fish-plant receipts to qualify for unemployment benefits in winter.

I HAD ONLY TO SIGHT down one of St. John's steep streets, lined with vividly painted Victorian row houses, to the waterfront to glimpse the future. There I saw the huge towers of Petro-Canada drill ships returned from the Labrador coast and the broad-beamed offshore service vessels that shuttle between the capital and the Hibernia oil field, 170 nautical miles east of the island. The Grand Banks blanket an enormous offshore oil deposit. Tapping this submarine petroleum won't be easy. The oil lies in "iceberg alley," where the Labrador Current sweeps icebergs southward from Greenland and the Canadian Arctic. Progress has been slower than expected, but

Hoofing it for cover, *a startled caribou makes tracks across a highway in the interior of Newfoundland island. A determined angler* **(right)** *fords a swollen creek*

offshore oil could provide as many as 4,000 much-needed jobs by 1990.

Zipped into a head-to-toe fluorescent orange survival suit, I helicoptered 200 miles offshore to Mobil Oil Canada, Ltd.'s semisubmersible catamaran drilling rig, anchored in 700 feet of water on the outer edge of the Grand Banks. Over a midday steak in the galley, Capt. Donald L. Brown, a Louisiana native who also had held a North Sea oil-rig commission, told me about his job.

"The Grand Banks is a much more rugged environment than the North Sea—more storms, fog, wind, and, of course, ice," he said. His crew, mostly Newfoundlanders, were undaunted by their fierce working conditions. "These are fishermen," Captain Brown explained. "They don't get frightened when the sea comes up." That day the unceasing North Atlantic swell was a barely perceptible roll. But inevitably I thought of the *Ocean Ranger*, a rig that went to the bottom in 50-foot seas with the loss of all 84 crewmen on February 15, 1982.

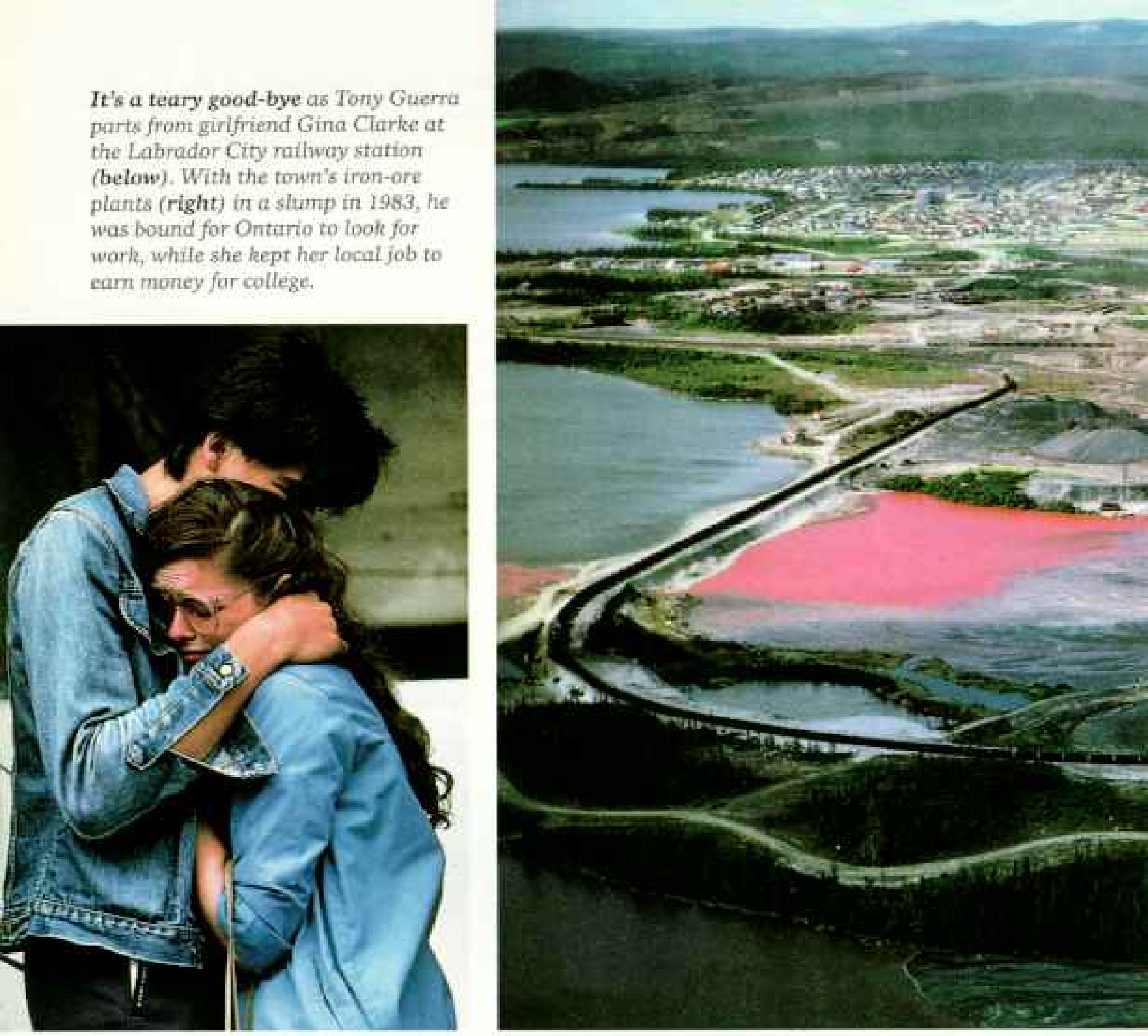
Newfoundland lost a supreme court battle with the federal government for ownership of the offshore petroleum. However, in February 1985 the two governments signed an accord that divides revenues and management responsibilities.

Energy minister William Marshall explained the government's goals in the offices of the province's Petroleum Directorate: "What we want to do is preserve our own culture and at the same time bring Newfoundland's per capita income up to the average Canadian's." Marshall added that the government hopes to use oil revenues

to reach Labrador's Pinware River and a run of Atlantic salmon. With settlement clustered on the coasts, the province's inland areas remain wilderness solitudes.

ROBERT S. PATTON, NATIONAL GEOGRAPHIC STAFF (BELOW)

*It's a teary good-bye as Tony Guerra parts from girlfriend Gina Clarke at the Labrador City railway station (**below**). With the town's iron-ore plants (**right**) in a slump in 1983, he was bound for Ontario to look for work, while she kept her local job to earn money for college.*



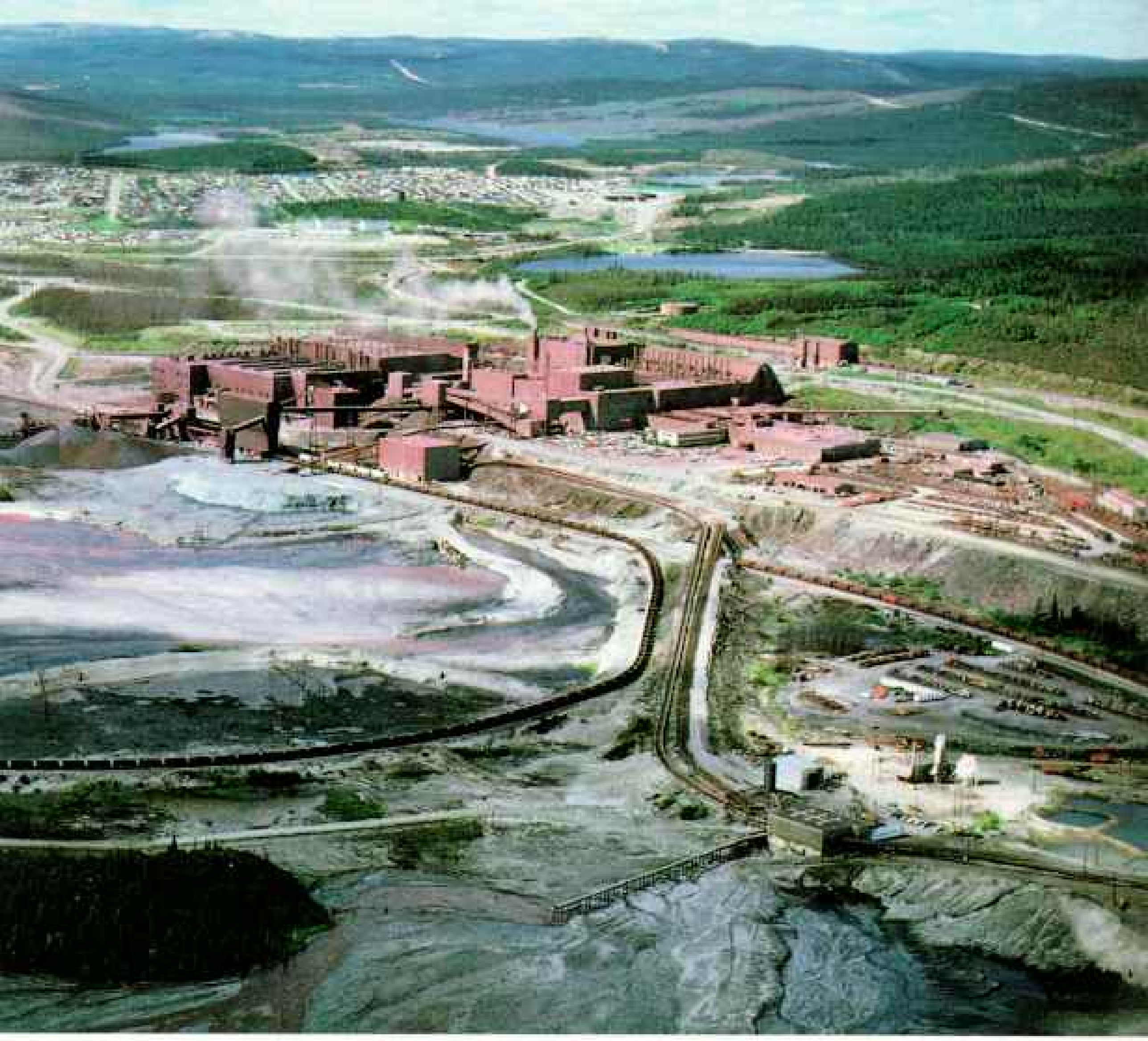
to make rural Newfoundland communities "happier, healthier places to live."

AN HOUR'S DRIVE south of St. John's, at Ferryland, I found proof of the sustenance that fish has provided to Newfoundland society. Here on the beach, salted, split cod cured to a delicate gold in the mellow Indian summer sun. The fish were laid out on portable pallets strung with wire mesh rather than on the traditional spruce bough platforms, or flakes. At the end of the day, instead of having to pick up each fish individually, the men simply rolled the pallets on rails into the fish storage shed.

Except for this labor-saving innovation, William Morry "makes fish" the way his family has done on this same stretch of beach for 250 years. He is one of the last Newfoundland merchants to practice the art of the light-salt sun cure that produces a food considered a delicacy in Spain, Portugal, Italy, the West Indies, and much of the northeastern United States.

"We're sort of family proud," William told me in a distinctive, mixed brogue—the Morrys are the lone Scottish family in an Irish enclave. William Morry, too, is worried about the impact of oil on the island. Morry is a realist. He knows that oil will be developed. But he supports the government's go-slow approach, so that the impact of change can be softened. An oil boom, says Morry, could knock his half-million-dollar annual business "into a cocked hat" by luring away the best of his employees.

"A boom would create dissatisfaction not only with jobs and pay, but also with the



type of life they're living," he said. "There's a way of living here that's pretty slow paced. We're healthier—I'm 68, and not too many people take me to be that. My father lived to be 87, and his father was 90-odd."

There never have been boom times here on the Southern Shore. Green waves break over "sunkers" (sunken rocks in Newfoundland dialect). In centuries gone by, I was told, the local people used to pray for a shipwreck—if possible without loss of life. The attitude is similar with respect to oil. People want the benefits to come ashore, but without loss of the life they've always lived.

Yet some would welcome change. I talked over tea with a young Ferryland couple, Adrian and Geraldine Kavanagh, in the modern split-level house that Adrian built with his own hands. He has worked on the oil rigs for seven years. Before that he had done a stint as a trawlerman. And both he and Geraldine had done what so many young Newfoundlanders have had to do to find work of any kind: go to the mainland. When they returned home, oil allowed them to stay. They believe it has given them more financial security than the fishery ever did.

"You hear older people, especially, saying, 'You're going to get people in from everywhere.' Well, it might liven it up," said Geraldine. "It might bring us out of our shells a bit. We might not be wrapped up in our Newfoundlandness so much. There are ways of preserving our own culture."

But if a unique Newfoundland culture exists, I didn't find it. The island is a patchwork quilt of folkways. On the south coast, West Country English can still be heard. On

Romping with sled dogs *that he keeps on a small island in summer, John Terriak* **(above)** *feeds and exercises them regularly. He moved with his family from Goose Bay to Nain, an isolated community on the subarctic Labrador coast, where he now practices the Inuit arts of his forebears—hunting, fishing, and carving material such as whale bone—as well as crafting jewelry.*

His wife, Johanna, and son Titus **(left)** *make bread dough in the kitchen of a home the family has largely rebuilt. Johanna visits cousin Miriam Brown* **(right)**, *who, despite her years of skill at making sealskin kamiks, has just stabbed her thumb with a needle.*

Inuit pursue old arctic skills with modern tools, even as they press land claims for their traditional territory.

National Geographic, May 1986

The tin stork *of the government health service delivers an Inuit mother and her newborn* ***(above)*** *back home, with help from Dr. Mary Kernohan, physician at Nain Nursing Station.*

Normally used for emergency situations, the airplane flew the mother, Maria Lampe, to Goose Bay, with its more comprehensive medical facilities, to have her baby.

Living in remote Nain requires self-reliance, neighborly help—and a close weather eye. Even such a routine chore as drying clothes ***(right)*** *can be interrupted by freezing snowfall—in early September.*

the west coast's Port au Port Peninsula Joe Benoît, then director of the Centre Français de Cap St. Georges Terre Neuve, told me: "I am a *French* Newfoundlander. I want to make that distinction."

THEN THERE IS LABRADOR. Separated from Newfoundland island by the Strait of Belle Isle, Labrador was annexed to Newfoundland in 1927 after generations of contention with Quebec over its ownership. Still, Labrador has its own history and a pioneering people jealous of their special identity.

I flew from Goose Bay, at the head of Lake Melville, 230 miles to Nain, Labrador's most northerly permanent settlement. "It's beautiful country looking at it from the glass bubble of a cockpit, but it can be

rugged down there," said pilot Clyde House.

Clyde knew what he was talking about. Two years before, he had survived a fiery crash in a whiteout. Grievously injured, he hollowed out a snow cave with his bare hands, then waited two days for rescuers. He spent eight months in the hospital, losing his right foot to gangrene.

Labrador's hinterland *is* beautiful in late summer. Mountains shepherd sunstruck lakes and white-water rivers; carpets of pale green caribou lichen are broken by thin, dark spires of black spruce. Even bogs have their barren beauty—black water criss-crossed by lacy threads of land, as if the whole creation had been laid down by a supernatural weaver of landscapes.

At Clyde House's Hunt River salmon camp I stood streamside with my guide, Billie Snook, basking in the glow of shirt-sleeve Labrador weather and the aftermath of a successful tussle with a scrappy four-pound Atlantic salmon. "It's beautiful to see fish comin' in this time of year," Billie said, referring to my salmon's bright, silvery color, a sure sign that it had recently entered the river from the Labrador Sea. "There's another week of fishing," he continued. "The salmon will go on up. They'll survive now."

For Labradoreans as for the salmon, survival in coastal Labrador is a seasonal struggle. The farther north I went, the truer this seemed. The glacier-scoured coast still evokes explorer Jacques Cartier's melancholy epithet, "the land God gave to Cain." Black lichen-encrusted skerries shelter the coastline. Outside the islands, icebergs sail these waters year-round.

By a *fluke* *a sailboarding visitor looking for whales is rewarded with a close encounter with two humpbacks in Bonavista Bay. The curiosity*

of the humpbacks, protected by Canadian law (as are all whales), was satisfied in one pass, and they swam off unimpressed.

As we flew over a treeless island shoaled in aquamarine, we saw circles of stones, used to anchor canvas tents, at an abandoned Inuit fishing camp. Bleak though it may be, waves of people—Maritime Archaic, Paleo-Eskimo, Labrador Thule, and white settler—have been drawn to this coast by its teeming fish, seals, and whales.

Nain (population 1,000) is the largest of the six coastal communities in northern Labrador and has the largest Inuit population. The fish plant is the economic mainstay, but this is a hunting society still. Caribou ribs hang out to dry on Nain clotheslines like striped shirts.

Aboard the *Silver Star*, a 50-foot fish collection boat, it was an eight-hour steam north to Cut Throat Island, an Inuit summer home for arctic char fishermen. It was Labor Day, and the last families had left just hours before we made anchor. I was rocked to sleep by gentle waves but woke in the night to a howling gale—my introduction to the treacherous Labrador weather and to the wretchedness of seasickness as we ran across the angry sea to safe anchorage in the lee of the Kiglapait Mountains. Storm-stayed for a day, we dined on a side of dried caribou ribs left on the beach by the departed Cut Throat Island fishermen. This was as close as I came—and close enough it was—to living off the land God gave to Cain.

BEGINNING with the 16th-century Basque whalers, outsiders have always established single-source economies in Labrador. The Labrador summer cod fishery has been pursued for generations by Newfoundlanders. The western Labrador company towns of Wabush and Labrador City sprang up around massive iron-ore developments, Churchill Falls around hydroelectric power. By contrast, native Labradoreans—Indian (Montagnais-Naskapi), Inuit, and white settler—have relied seasonally on a variety of resources: fishing, sealing, hunting, trapping, boatbuilding, and, since World War II, wage earning.

The peoples are bound together by a dedication to a way of life and, in many cases, by blood ties. "It's what academics at Memorial University in St. John's call economic pluralism," explained Tony Williamson, then director of the university's Labrador Institute of Northern Studies, at the Canadian air base at Goose Bay.

Williamson, born in New York, is a "come-from-away," who over three decades has become a Canadian citizen committed to the Labrador way of life. I asked him how Labradoreans would cope with the new wave of outsiders, the highly skilled and specialized technocrats accompanying the search for energy resources in the north.

"I think they want to be in on the changes in Labrador, and they know there are trade-offs and costs associated with those changes," he said. "But they also want some grip on the pace with which this all happens and the manner in which it happens."

Williamson's words stayed with me. Better than most, they crystallized the struggle that is pushing and pulling at Newfoundland and Labrador as they enter their fifth century. I heard them echoed elsewhere—officially, in the government's cautious policy on oil development and, repeatedly, in casual conversation. As I walked the gravel footpath and boardwalk that curled through dusk-hushed François, John Fudge articulated for me an attitude many Newfoundlanders must share: "You have your livelihood and you have your freedom. What more can you ask of life?"

On the return trip from François, I again found myself drawn to the coastal boat's deck to gaze at the mountainous south coast. Its austere loneliness seemed to hold out some mystery, to ask a question. I thought of the Anglican confirmation service that I had attended in the little Gothic church in François that was built like a ship—arches supported by carved knees as in schooner hulls. A ten-year-old boy played the guitar and sang Bob Dylan's "Blowin' in the Wind." One of the ballad's plaints, "How many years can a mountain exist before it's washed to the sea?" seemed to have a poignant relevance for contemporary Newfoundland and the scene before me.

My odyssey through Newfoundland had left me feeling that many of its traditions inevitably would be eroded by oil development or things unforeseen that might come ashore in the decades ahead. But Newfoundlanders would stand like the Rock itself before the winds of change. □

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To save the gorillas: Dian Fossey's legacy

THE DEATH by brutal murder of Dian Fossey—that extraordinary person who devoted her intellect, her emotions, the very depths of her being to the mountain gorillas of Africa—must not have been in vain. Dian came to her life's work somewhat late. Though Africa was her dream since childhood, she had worked as an occupational therapist before making connection with the great paleoanthropologist Louis S. B. Leakey. It was Leakey's particular genius not only to find, classify, and bring to the world's attention significant remains of mankind's ancestors, but also to inspire, encourage, and guide a generation of scientists, especially in primate studies. Dian Fossey was one of those.

Dian began her work in the Virunga Mountains in 1967 and was shortly given financial support by the Society's Committee for Research and Exploration, funding that continued for more than a decade. If she had ever planned to be solely a detached, dispassionate academic observer of the mountain gorillas, that plan was soon abandoned. To do good science, she moved among the gorillas, almost as one of them.

As she did, and as they accepted her, an intimate bond was forged that transcended the line between one primate species, the human, and another, the gorilla. Her science was first-rate. In her latter years Dian was more an advocate for the threatened gorillas—her family really—and she defended them as fiercely as any mother will defend her children. The enemies were implacable, if not evil—poachers and the press of human population in Rwanda. Her defense was single-minded, and Dian could be difficult, stubborn, and aggressive. Having proved that gorillas were usually retiring, peaceable, and vulnerable, she needed sterner qualities to help save them from final destruction. Had it not been for Dian Fossey, there is no doubt in my mind that the mountain gorilla would by now have joined the list of extinct species. In 1977 a gorilla she named Digit ("I was unashamed to call him 'my beloved Digit' ") was—murdered is the word. She established the Digit Fund to aid gorillas. In Dian's memory, contributions for gorilla research and protection may be sent to the fund c/o Rane Randolph, Treasurer, P.O. Box 25, Ithaca, New York 14851.

BOB CAMPBELL

Many scientists who have worked under Society grants have faced risks, risks they weighed in advance. None other has paid such a terrible price. Dian Fossey was larger than life. May the legacy of her work, her passion, be larger than death.

Gilbert H. Grosvenor

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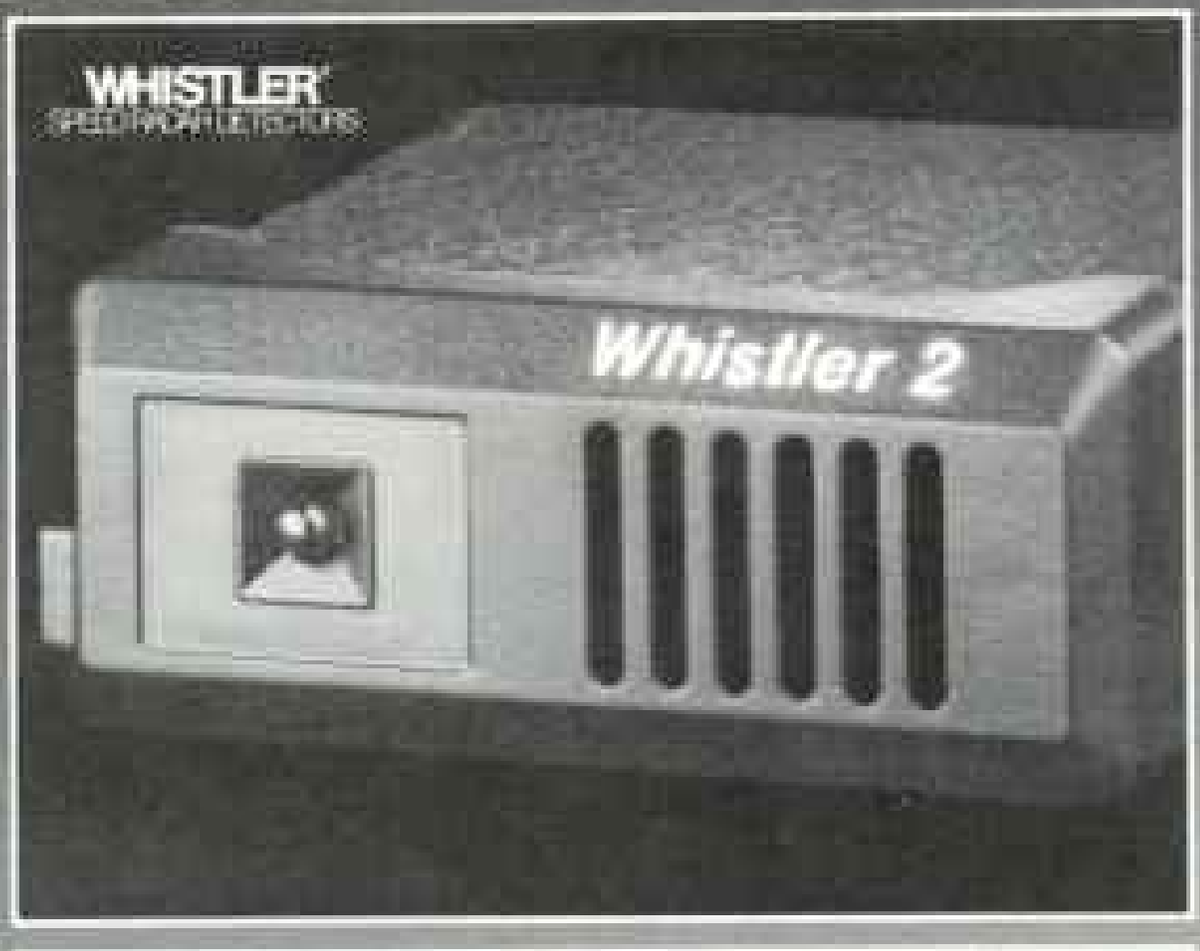

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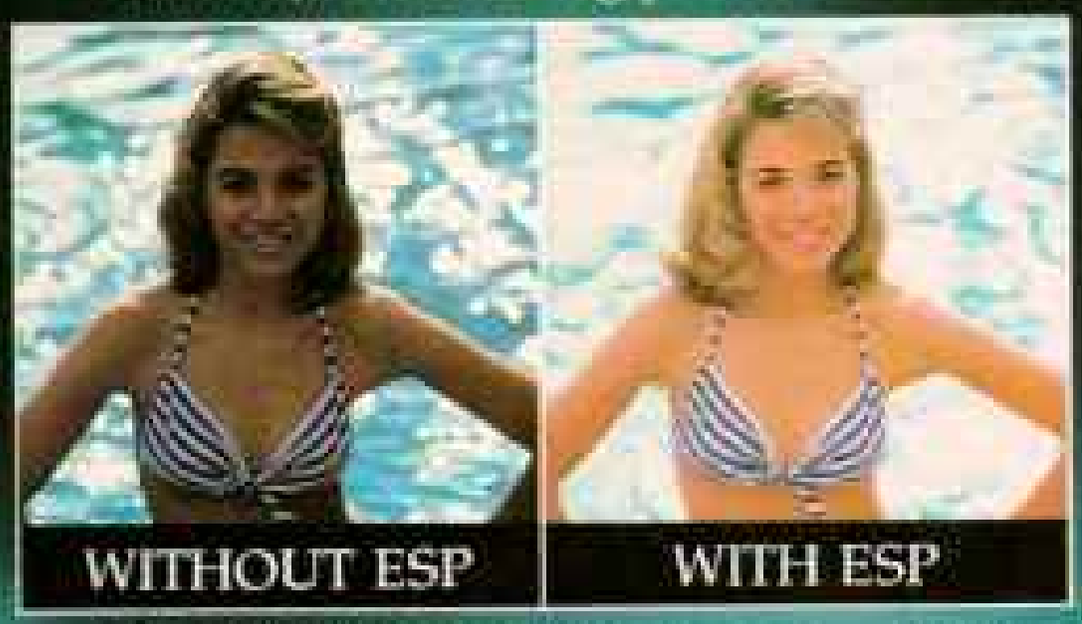

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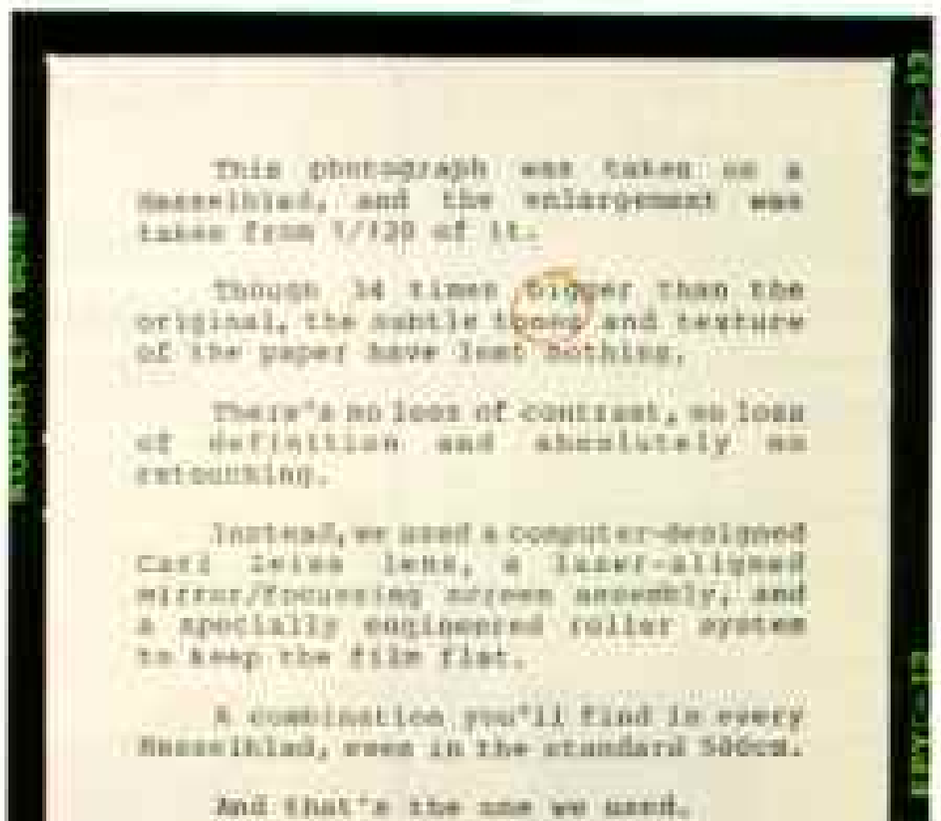

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Members Forum

Cowboy Artist

Charles M. Russell saw and lived life that we today can never see except in his paintings. But I doubt that Charley ever saw a 1923 postage stamp with a 1902 postmark, as seen on the envelope depicted on page 80 of the January 1986 GEOGRAPHIC.

Wendell Shaw
Erie, Kansas

The Thomas Gilcrease Institute of American History and Art, owner of the envelope, was unaware of this contradiction until dozens of our readers pointed it out. Most likely, the original stamp fell off and was replaced with one of later issue.

Thank you for your excellent article on Charley Russell; it took me back in time and space to my boyhood days in Montana. The photographs show a Montana unchanged from what I recall. Apparently though, Square Butte (pages 76-7) has shifted about 70 miles west of where it used to be. For most of my early years, it was the first landmark I saw every morning, but that was when it was located just south of Geraldine.

Glen Hicks
Statesboro, Georgia

Montana has at least two Square Buttes. Several Russell pictures include the "eastern" Square Butte, but the great formation we show, located southwest of Great Falls, was his favorite and figured in many paintings. As Russell wrote from California shortly before he died, "Califonia is all right but I can't see. . . squar butte from here."

Your Russell article was a treat. Another important feature of his work is his sure knowledge of men and horses. A case in point is "When Shadows Hint Death" on pages 82-3. The men are not petting their horses to quiet them; they are pinching off their nostrils to prevent them from nickering to the Indian horses. Clearly, neither horse finds this pleasant.

Kelly H. Clifton
Madison, Wisconsin

Queensland

I wish that the innocence of those two youngsters running out into the sunshine to play (January 1986) would teach us grownups a lesson. Namely, that it is we who teach children to hate. God created us all equal, and I hope and pray that we act accordingly during the coming times.

Hans H. Welcker
Whiting, New Jersey

Despite containing an apparently limitless wilderness, Queensland leads developed nations of the world in the rate at which it is degrading and destroying rain forests. Occupying less than 8,000 square kilometers along a thin edge of the east coast, its rain forests contain the most primitive, some of the most vulnerable, and among the least studied plant and animal species anywhere.

Steve Hall
Wide Bay Burnett Conservation Council
Kin Kin, Queensland

The statement that Australian beef is "highly prized in the U. S. and other lands, for there has never been hoof-and-mouth disease here" infers that hoof-and-mouth disease exists in the U. S.

After 21 years in the meat industry, I can assure you that the real reason Australian beef is highly prized in the U. S. is that it is an inexpensive, lean, low-grade though wholesome meat that is used in chopped meat products, which include hamburger. Though hoof-and-mouth disease could have been part of the original reason for importing foreign beef, it has been eradicated in the United States.

J. H. Newkirk
New Salisbury, Indiana

In the depiction of Australia's Prehistoric Menagerie (pages 38-9), a python is named *Montypythonoides riversleighensis*. Is this designation some sort of joke?

Mike W. Fisher
Eureka, California

Dr. Archer hoped to evoke a chuckle by naming his find for the British television comedy show "Monty Python's Flying Circus."

Switzerland

To me, Switzerland represents the embodiment of the intent of the best of our founding leaders: No foreign entanglements. Wide diversification of governmental powers. The right (duty) to keep and bear arms. A people with the recognition of a single justification for the military—that of individual self-defense.

C. R. Estes
Camarillo, California

There may be those who scoff at the Swiss for maintaining their huge militia army and carrying through such extensive civil defense measures, but history provides justification. In both World Wars Germany believed taking Switzerland would be too costly in lives and money for what it was worth. The reason was Swiss preparedness and determination to resist any attack.

Frank W. Goheen
Camas, Washington

The Swiss Army is definitely no match for the latest enemy that invades from surrounding industrial countries: air pollution. According to a 1985 report, 36 percent of all Swiss forests are damaged by acid rain. The problem is especially acute in the Swiss Alps, where the *Bannwälder*—protective forests against avalanches—are affected. If the dying of the forests cannot be halted, entire Swiss villages below the Bannwälder will have to be abandoned.

Professor Anton Andereggen
Lewis and Clark College
Portland, Oregon

The GEOGRAPHIC will address the problems of global air pollution in a forthcoming issue.

Nicaragua

In his article on Nicaragua (December 1985) Mike Edwards says, "About a third of Nicaragua's farmland has been expropriated." This gives the impression that private landowners were victimized. Actually 20 percent of the cultivable land was owned by the Somoza family and associates; this was converted by the Sandinistas into state farms. Other lands seized included that owned by delinquent taxpayers and idle farmland. The government took no land from private landowners without compensation.

John Burton
Washington, New Jersey

Usumacinta River

We read with interest your article on the Usumacinta River (October 1985), especially the section about the intriguing petroglyph site of Planchón de las Figuras.

We would like, however, to point out potential problems with the practice of adding a "temporary outline" of chalk to highlight petroglyph figures. Chalking inevitably records the biases of the chalker. Chalk seldom weathers away no matter what the exposure to natural elements. It introduces alien material into the rock surface, which may increase the rate of deterioration. It would have been advisable for the recorders to use their lighting equipment to sidelight the glyphs for time exposures. Please advise your readers never to apply chalk to rock art.

Ken Hedges, President
American Rock Art Research Association
El Toro, California

The researchers did take sidelighted photographs of the 68 petroglyphs, although many are eroded almost beyond recognition. However, it seemed necessary to use chalk to bring out the images clearly. A special chalk was used and washed off immediately, leaving no damage. The entire album of photographs has been deposited with the Instituto Nacional de Antropología e Historia in

Mexico City and will eventually be published, according to archaeologist Roberto García Moll. We agree in principle; Chalk should not be applied to rock art.

Dian Fossey

I was greatly saddened to learn of the death of Dian Fossey. In the years I spent on gorilla photographic assignments, I naturally got to know and understand her well. Of all my experiences with wild animals, the times I spent with the gorillas remain the most exciting and rewarding. The gorillas have lost a great champion for their cause, and I fear none will come after with the same strength of character and determination to help the gorillas survive.

Bob Campbell
Nairobi, Kenya

The Campbell and Fossey articles appeared in January 1970 and October 1971. Dr. Fossey's last report was published in April 1981.

With the senseless and brutal murder of naturalist Dian Fossey in Rwanda, who if anyone will continue her work with the mountain gorillas? I, along with thousands of other National Geographic members, would appreciate updates on future events at the Karisoke Research Centre, where Miss Fossey's love for the noble gorilla ultimately cost her the ultimate price: her life.

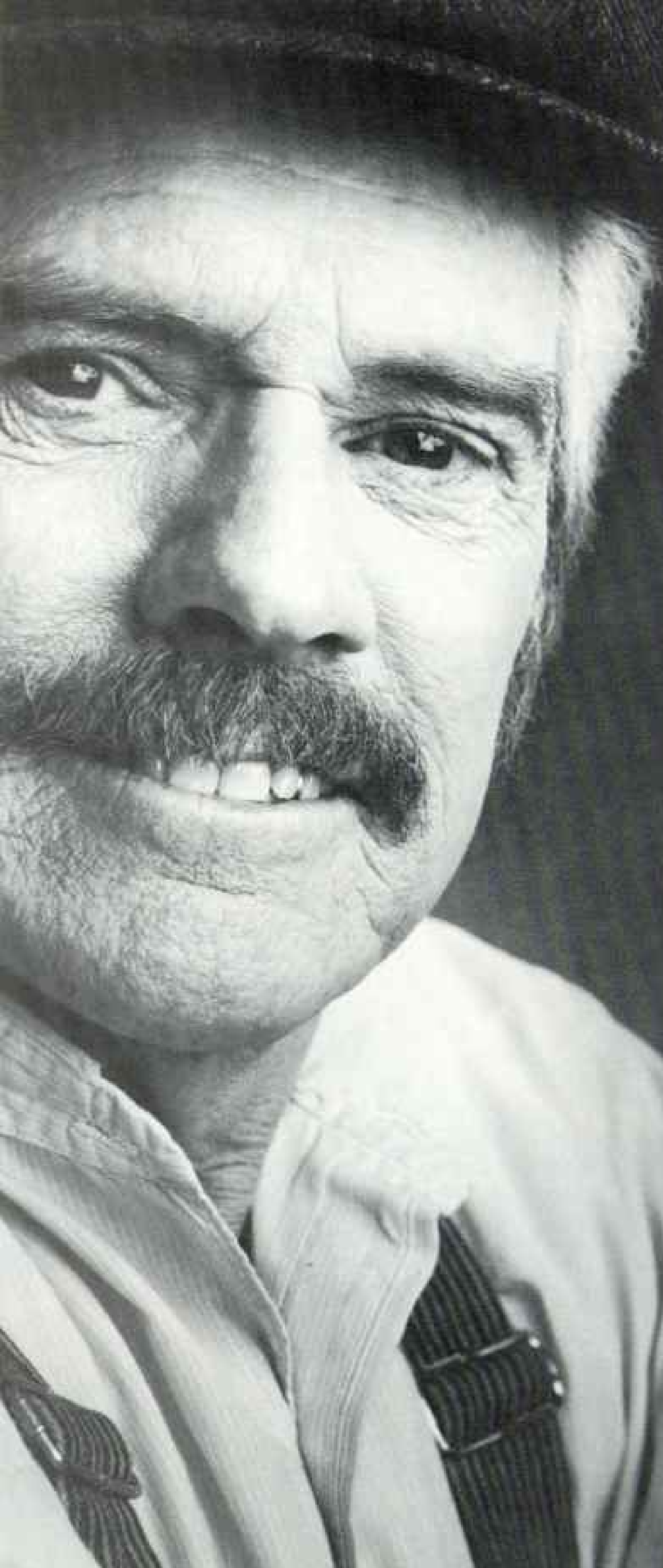
Nancy J. Ertel
Long Beach, California

As I mourn the death of this magnificent and courageous lady, I wonder is the Society doing anything to help this woman's life goal in saving these beautiful creatures? I also am deeply concerned about what justice will be brought to the murderer of Miss Fossey. Will the killers be found?

Marilyn Daub Shine
Hazen, North Dakota

The Digit Fund (see President's Page), international wildlife groups, and the researchers Dr. Fossey trained are determined to see that the work at Karisoke continues. The Society's Committee for Research and Exploration will entertain requests for grants for gorilla research from qualified scientists. In Rwanda, where many grieve the loss of one who "gave herself to our animals," officials are actively investigating the murder. In January Dr. Fossey was buried near her beloved Digit in the Parc des Volcans.

Letters should be addressed to **Members Forum,** *National Geographic Magazine, Box 37448, Washington, D. C. 20013, and should include sender's address and telephone number. Not all letters can be used. Those that are will often be edited and excerpted.*



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Photographed by K. Wothe *Lion-tailed Macaque: Genus: Macaca Species: silenus Adult size: Length of head and body: males, 51—61cm; females, 46cm Adult weight: Males, 6.8kg; females about one third smaller Habitat: High evergreen rain forests in the Western Ghats of southern India Surviving number: Estimated at a few thousand*

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Shy by nature, the lion-tailed macaque usually remains in the upper forest canopy feeding on fruits, nuts, flowers and insects. Although the most arboreal of all macaques, it will often climb down to the ground in search of food or to move to another tree. Lion-tailed macaques live in small groups of about 10 to 20 individuals in secluded and undisturbed forests. Marked by a distinctive shaggy mane, this noble-looking animal is one of the world's most endangered primates today.

Nothing could bring back the lion-tailed macaque should it vanish completely. And while photography can record it for posterity, more importantly photography can help save it and the rest of wildlife.

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The survival of the lion-tailed macaque will depend upon the protection of its forest home. Remaining populations have taken refuge in a few isolated forest areas that still exist. With its expressive powers of communication, photography can help promote a broader awareness and understanding of the urgency to save not only the macaque, but the world's rain forests and the astonishing diversity of life these irreplaceable ecosystems sustain.

And understanding is perhaps the single most important factor in saving the lion-tailed macaque and all of wildlife.

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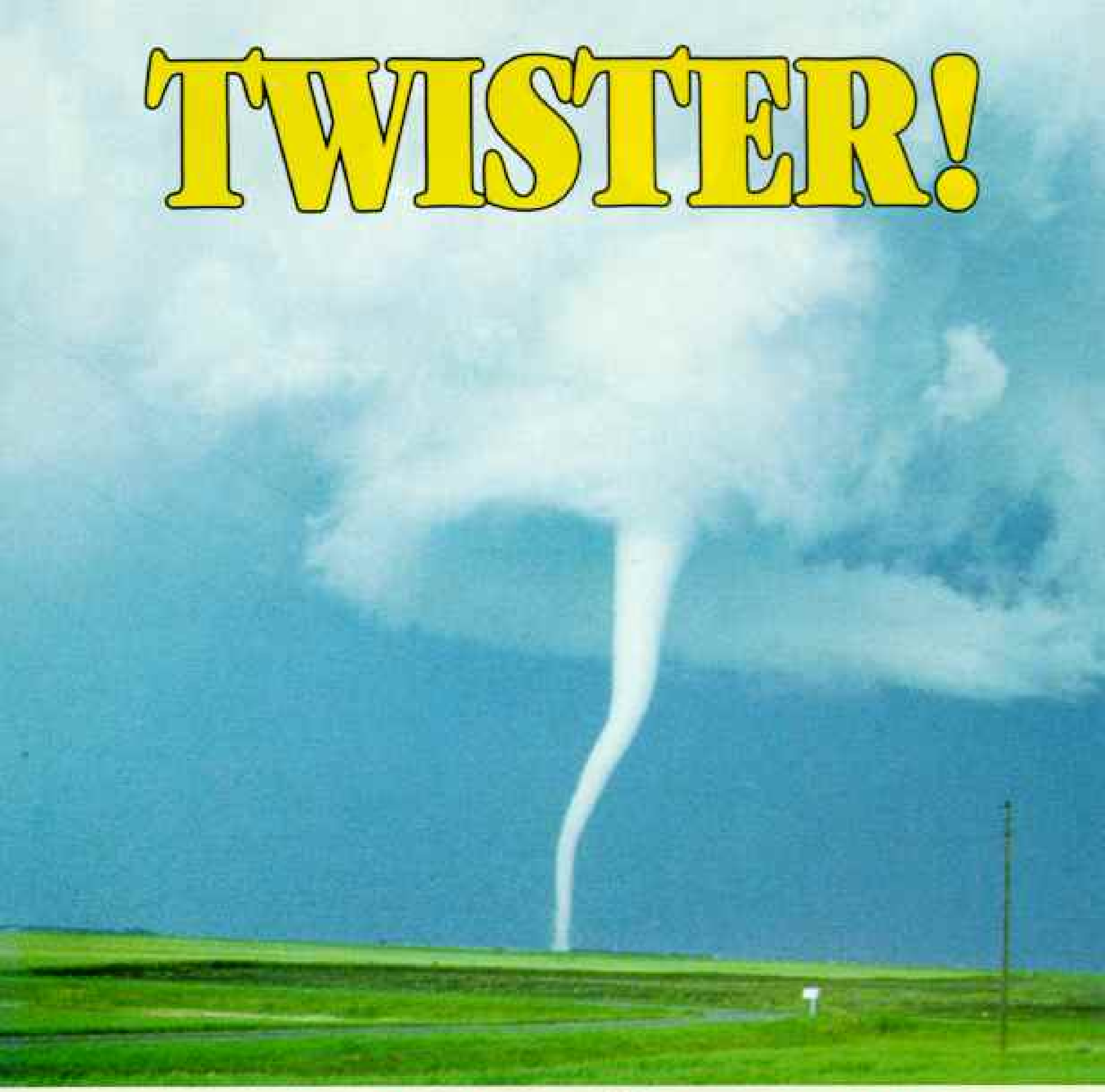

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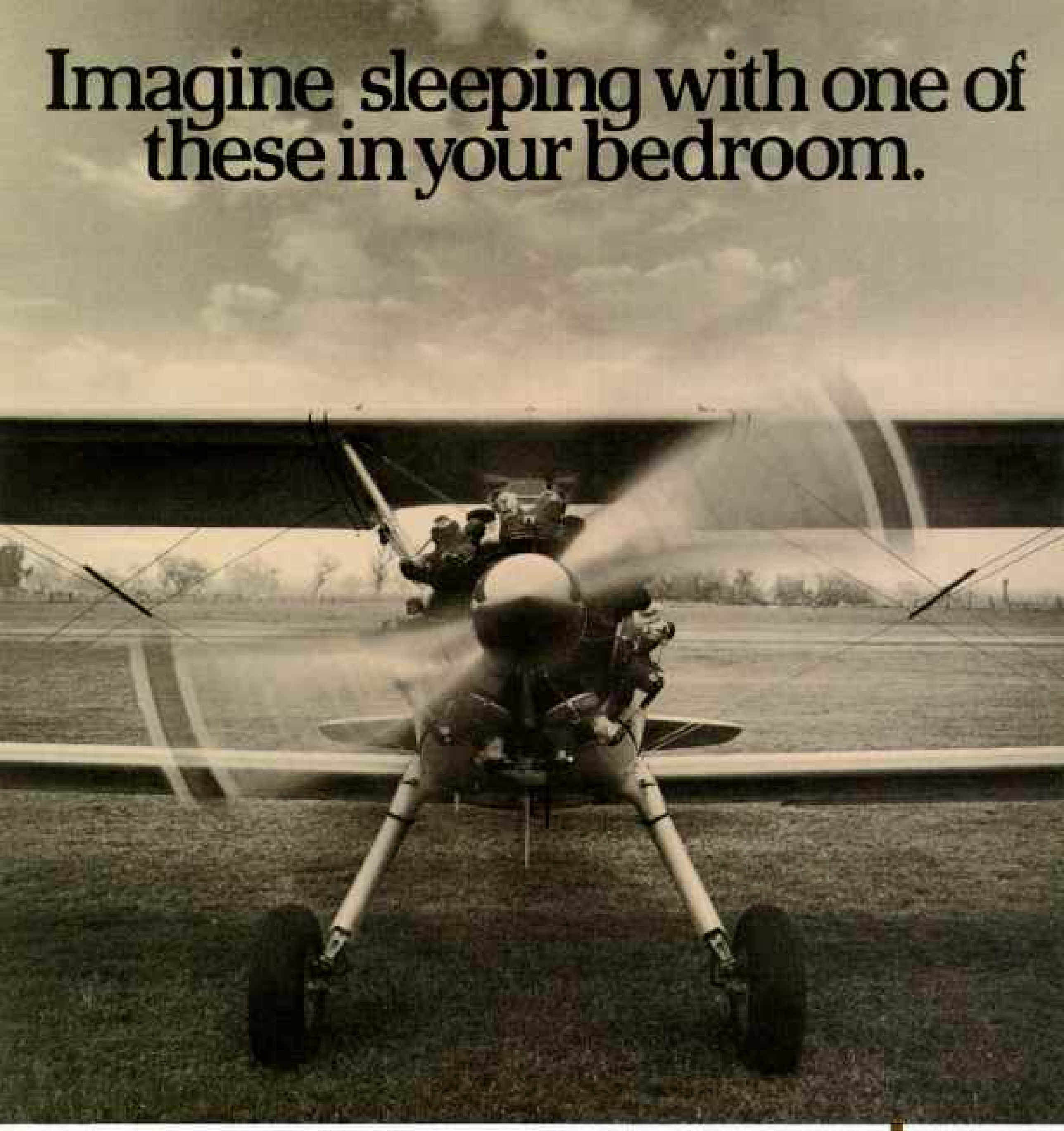

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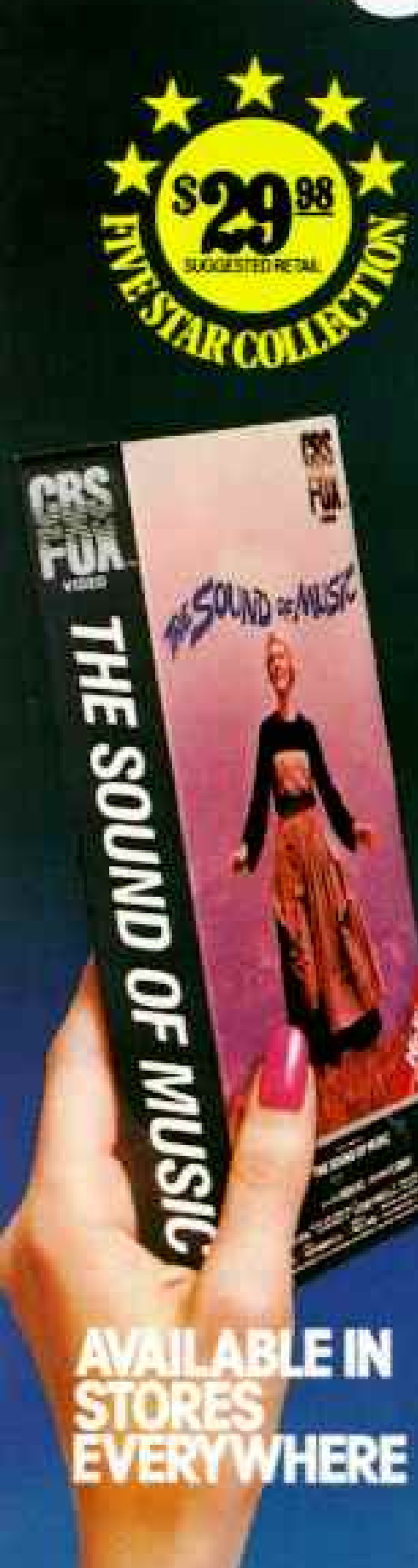

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On Assignment

BY WILLIAM T. DOUTHITT (ABOVE); KEVIN T. GILBERT

MARRIED TO A FOOTLOOSE LIFE, journalistic couples have produced some of NATIONAL GEOGRAPHIC's most memorable coverage since the magazine's earliest days, when Elsie May Bell Grosvenor accompanied Editor Gilbert H. Grosvenor to far corners of the earth. Today, however, a shared profession is often shared at a distance, as GEOGRAPHIC illustrations editor ***Bill Douthitt*** learned after his marriage to free-lance photographer ***Karen Kasmauski*** three years ago.

Bill left his desk job for several months to undertake a photo assignment on the Susquehanna River, where he documented scientists monitoring water pollution (***right***), for the March 1985 issue. Soon after, Karen was prowling Hampton Roads, Virginia, for an article in July 1985 and then began coverage of Tennessee (***above***) for the story in this issue.

Like many photographers, the couple are driven by a curiosity about other people's lives and a desire to "broaden our own experience through the medium of

photography," says Bill. "We both grew up in military families and were used to separation and moving into new situations," adds Karen, "so we understand each other." And if trying to be together in this commuter marriage means spending a lot of time in the Atlanta airport, as Bill says, "So be it."

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