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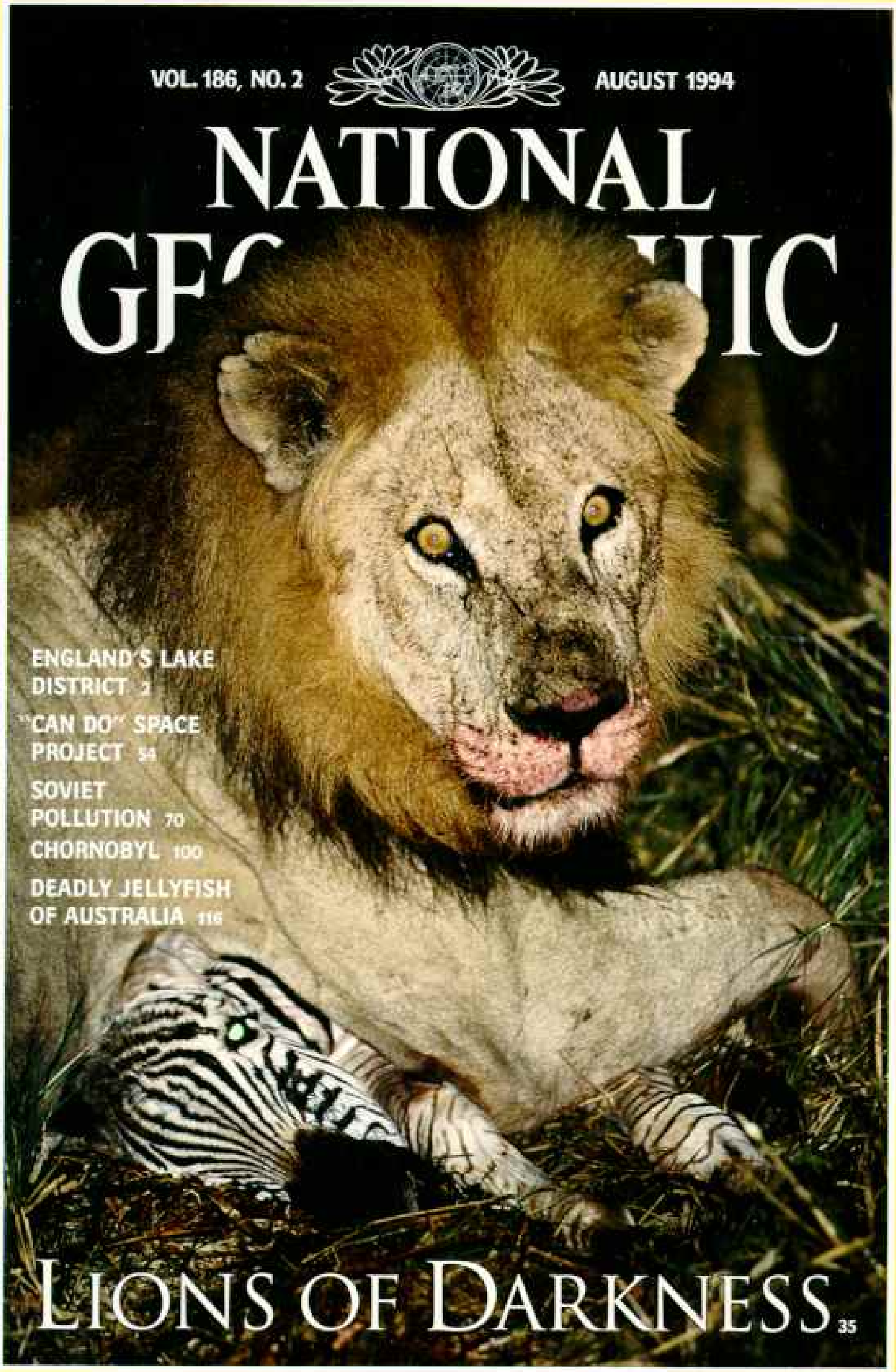

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NATIONAL GEOGRAPHIC

AUGUST 1994

COVER: The king of beasts guards his kill during an African night in Botswana's Chobe National Park. Photograph by Beverly Joubert.

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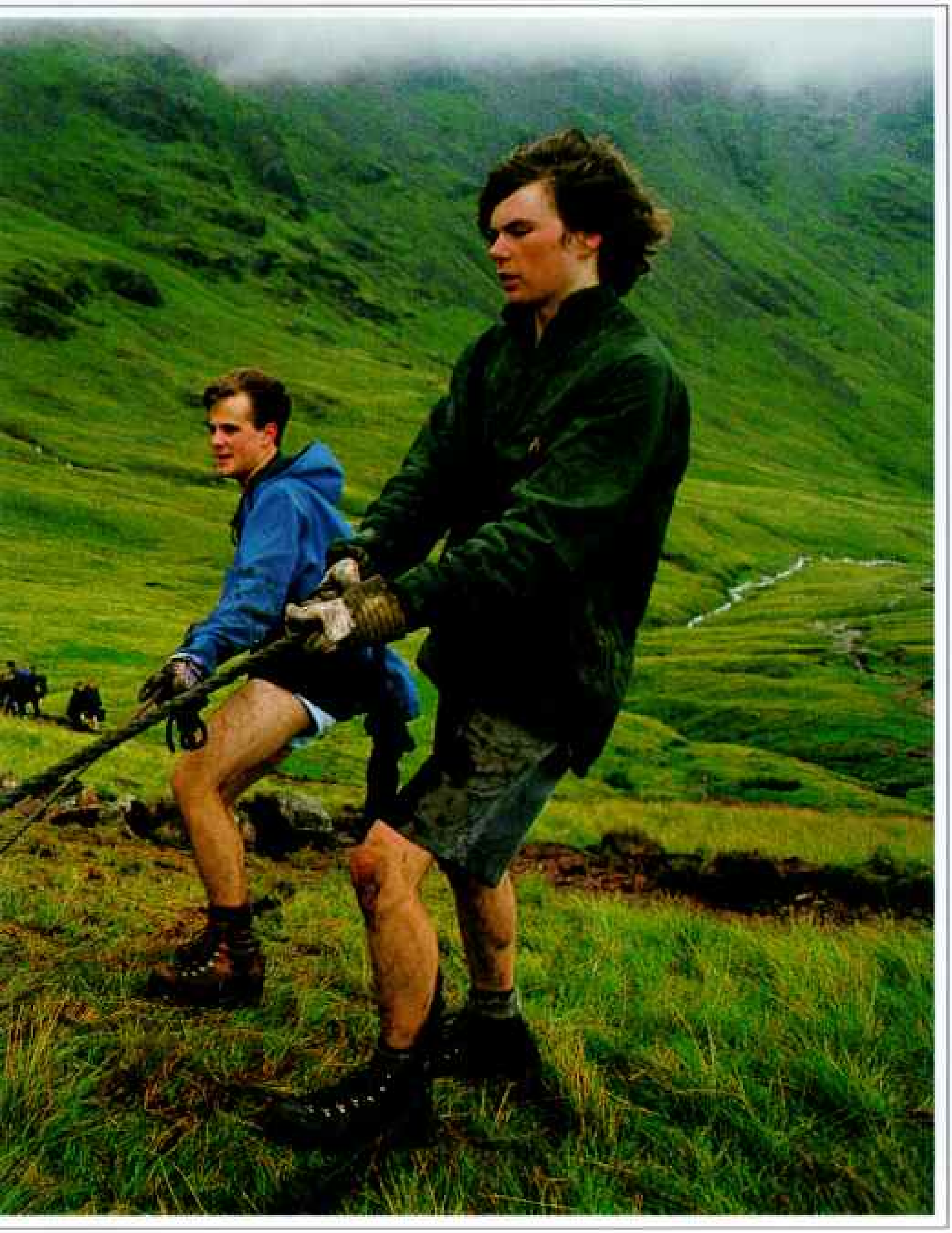
ENGLAND'S LAKE DISTRICT

BEAUTY

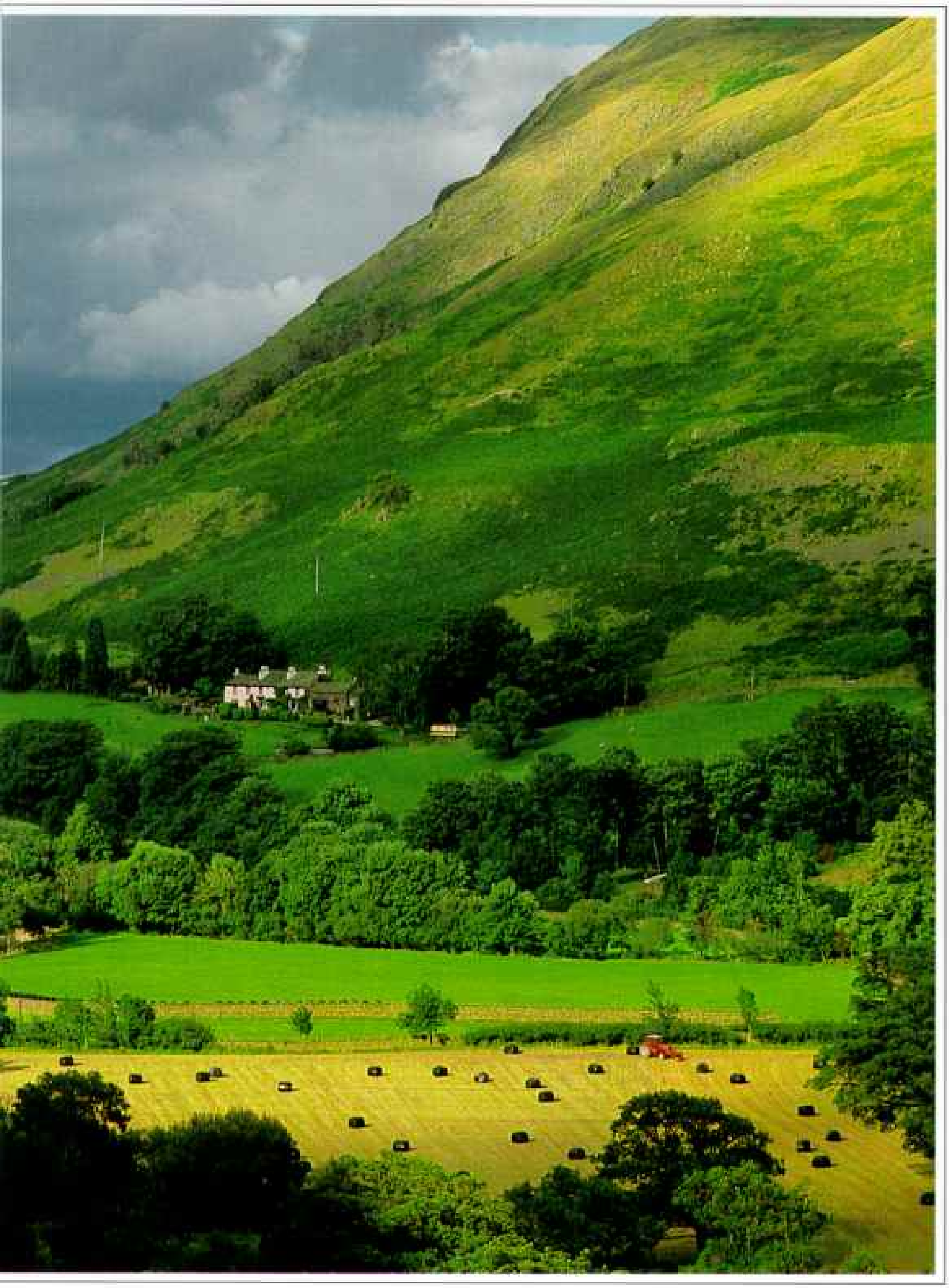
Pitting muscles against mountains, volunteers haul boulders to shore up overused trails in England's fabled lake country. The luminous mists and airy, sheep-cropped valleys that

BESIEGED



bewitched English Romantic poets still delight the eye. But a crush of visitors brings new woes to a place William Wordsworth described as "a blended holiness of earth and sky."

Painterly skies daub sunlight and cloud shadows on the shores of Ullswater, one of 16 major lakes that give England's Lake District its name. A century-old steamer carries tourists through scenery that drove poet Samuel Taylor Coleridge to sublime



distraction. "My glass [mirror] being opposite the Window, I seldom shave without cutting myself," he wrote of a stay in the Lake District two centuries ago. "I offer up soap & blood daily, as an Eye servant of the Goddess Nature."

"It's all technique—keepin' 'em well-balanced on their backsides," farmer Joss Naylor says of the nimble art of shearing sheep in the hamlet of Wasdale Head. "Takes me five minutes. Fleece comes off in one piece." Sheep have been a part of life in Cumbria—the

English county that cradles the Lake District—for a millennium. The local Herdwick breed, a cold-hardy species whose wool is used mainly in rugs, may be descended from lambs introduced by Viking settlers.

Mud pies and monkey business offer antidotes to city stress for vacationers in the Lake District. "It's a little Switzerland in our backyard," exults dad Jeremy Chalder, an engineer from the town of South Shields. Maybe so, but England's favorite backyard can sometimes seem as crowded as home: Twelve million tourists a year visit the Lakeland to trek, paddle, or simply soak up the pastoral grace of a region nearly twice the size of Los Angeles. On national holidays, country lanes glint with long lines of crawling cars—and windswept mountain peaks are stubbled with hikers. In terse local dialect, a sign of the times (right) safeguards a farmer's sheep from passing motorists.

By BILL BRYSON
Photographs by ANNIE GRIFFITHS BELT

THEY STARTED COMING a little before 8 a.m., drawn by a watery sun and the hope of a fine day. By 9, when the shops began to open, the lakeside town of Bowness on Windermere, in the heart of England's Lake District, was beginning to feel busy. By 10:30 the sidewalks were thronged with tourists, and every road into town was backed up with hundreds of vehicles, most bearing a backseat full of bouncing children and a front seat with a dad saying, "I told you we should have started earlier." Another summer weekend in the Lake District was under way.

Few places anywhere offer a more beguiling interplay of hills, lakes, and soft green valleys than this small corner of northwest England in the county of Cumbria. The rugged peaks, wild, high moors, and wandering vales contain a drama and grandeur elsewhere lacking in the tranquil landscape of England and have provided inspiration for generations of poets and artists. But for all its visual glory, the Lake District is painfully modest in its dimensions—just 39 miles from top to bottom, 33 miles across at its widest point—and, for much of the year, even more painfully crowded.

Some 12 million visitors, roughly a quarter of England's population, pour into this compact landscape every year. That is more than four times the number of people who visit America's Yellowstone National Park, and in an area just a quarter the size.

From Easter to late September, but increasingly in the off-season as well, they come to exult in the storied landscape or simply to putter about in the shops and museums of the little towns that line the lakefronts or lie scattered across the valleys. What they find, all too often, is thousands of others—as many as 250,000 on the busiest days—trying to do the same thing.

On a summer Saturday in Bowness, there seems no question of it. "I can't explain it," a bobby remarked to me in a tone of wonder as we watched the shuffling masses of day-trippers. "It's like they *want* to be with thousands of other people. There's miles and miles of glorious countryside all around here where you can walk all day and scarcely see a soul, but they don't seem to want that."

Even on a weekday in June, long before the late-July start of school vacations that marks the beginning of the Lake District's most frantic six weeks, Bowness was looking lively. Buses from all over the north of England were disgorging streams of mostly elderly visitors, and the cafés and tearooms were doing a brisk business. I had to wait ten minutes for a seat at one and was asked if I minded sharing a table with strangers. I did not. My dining partners were a young family from Lancashire, Alan and Brenda and their two small sons, Darren and Danny, who were up for the day.

"We come once or twice a year," Alan explained. "The kids love it," Brenda

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BILL BRYSON, a transplanted American living in the north of England, keeps his cross-Atlantic connection strong; he has just completed a book about the English language in America. His latest article for NATIONAL GEOGRAPHIC was on the flood in his hometown, Des Moines, Iowa (January 1994). Among ANNIE GRIFFITHS BELT's previous photographic credits is "To Scotland Afoot Along the Pennine Way" in the March 1986 issue.

added. "There's so much to do—miniature golf, riding the lake steamer, feeding the swans, shopping." Did they ever get out into the countryside? "Well, you know, we like to drive through it to get here," Brenda said. "It's very pretty," she added as an afterthought, as if to confirm that she had noticed.

"There is a kind of elitist attitude with the lakes," an old friend told me later, "a feeling that people should get out into the hills and do something healthful instead of just poking about in Bowness. But if that's all they really want to do, then why shouldn't they?"

Why, indeed. Twelve miles away is a place called Patterdale. Approached over

Tranquillity takes a backseat in Bowness on Windermere, a tourist hub on the region's largest lake. How bad is the weekend parking? "Couldn't say," sighs one local. "On those days I leave the car at home." In the past few decades tourism has slowly eclipsed agriculture in the Lakeland.

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a high, lonely road through the hills, Patterdale appears as a sudden burst of splendor: A symphony of steep, muscular hills, dotted with sheep and mottled with patchy sunshine, framing a tightly confined valley of low white farmhouses and small, neat, vividly green fields. Far below, a tractor trundled slowly across a field, unfurling in its wake a golden strip of new-mowed hay. It was the only sign of life. Bowness and its tourist hordes seemed a million miles away.

Like Bowness, Patterdale lies within the 885 square miles of the Lake District National Park, formed in 1951 to help preserve this rare and vulnerable landscape. It is the largest of the ten national parks in England and Wales (Scotland has none), but, as with the others, the designation is really a misnomer since the land is neither owned by the nation nor is it in any conventional sense a park. It is, rather, a lived-in landscape, full of towns and farms, with a resident population of 40,000. All but a small fraction of the land is in private hands.

Unlike U. S. national parks, which often aim to preserve wilderness, British

Irish Sea

THE LAKE DISTRICT

A small, gleaming emerald in a crown of natural treasures, the Cumbrian heartland is the domain of sky-lacquered lakes, glacial valleys, and chiseled peaks—including England's highest mountain, 3,210-foot Scafell Pike. Stone Age farmers, Celtic peoples, and invading Norsemen cleared the Lake District's ancient forests, tempering the wilderness with lush, parklike pastures.

Today the 885-square-mile Lake District National Park remains a working landscape. A patchwork of private farms, it is accessible through some 1,800 miles of public trails and bridle paths.

parks inevitably include residents. These parks were created so there could be a way to exert some control over the speed and nature of change, not to prevent it altogether. Unfortunately, the various authorities have little power, relying primarily on persuasion to resolve myriad demands.

Tourism is a mixed blessing. Visitors bring 660 million dollars a year to the local economy, making the Lake District one of the most prosperous corners of Britain, but in doing so they unwittingly trample ancient footpaths into muddy gullies, crowd locals from their pubs and park benches, and turn pleasant villages into teeming emporiums of souvenir shops. Even in the still repose of Patterdale their effect is felt.

"We get 100,000 visitors across our land every year," says Alan Wear, who farms 1,700 acres with his brother, as their forebears did for at least 200 years before them. "If just one in a thousand forgets to shut a gate or can't be bothered, that's a hundred times we have to go out and round up our sheep."

A lovely invader, feathery, waist-high bracken ferns tint a hillside luxurious green near Sandwich. The fern—a tenacious native species that takes over deforested plots—produces toxins deadly to livestock. Park officials have resorted to herbicides to control its spread.

In the measured drawl of a true Lakelander—a form of speech that swallows definite articles and does taffy pulls with long vowels—Wear told me how he had recently found seven ewes, all carrying lambs, drowned in a nearby beck, or stream. "Somebody obviously had a dog up there and let it run free. Dog naturally chased after sheep, and sheep panicked and jumped in beck trying to get away. And t' owner probably thought dog was just having a bit of harmless sport."

WINDERMERE is the largest and most celebrated of the Lake District's 16 or so lakes. I say "or so" because the number is entirely a matter of definition. The region is packed with hundreds of bodies of water, relics of the last ice age 10,000 years ago, but most are deemed too small to be called lakes. They are known instead as tarns, one of the many Old Norse words, like beck,

dale (valley), and fell (hill), that pepper the local dialect and serve as constant reminders that this was once a Viking stronghold.

Despite its rather grand status, Windermere is a modest body of water indeed, little more than ten miles long, seldom more than a half mile wide, and in places only a few feet deep.

"It's just not big enough for the number of people who want to use it," says Tony Hill, a former policeman who now works as a national park ranger on the lake. "On a busy day we can get up to 1,600 powerboats—plus sailboats, dinghies, canoes, inflatable rafts, passenger steamers, and a ferry. It's a wonder sometimes you can see the water."

It's also a wonder that serious injuries aren't more common. To give me some sense of the potential danger from overcrowding on the lake, Steve Tatlock, a genial young ranger, agreed to take me out on the water a few days later when the weekend crowds had thinned. We clambered into the park's launch, a sleek, American-built beauty that was clearly designed for speed, as I came instantly to appreciate when Tatlock threw open the throttle and we shot off at a velocity I had previously associated with cartoons.

"This is the kind of speed waterskiers like," Tatlock shouted at me over the roar of the engine as we dodged a moored cabin cruiser and skittered around a wooded headland. "Imagine going this fast on a busy day when the water was crowded."

At the moment there is no speed limit on Windermere; the park doesn't have the authority to arbitrarily impose one. But it hopes to change local bylaws and have a law enacted by 1995 limiting the speed to ten miles an hour.

Surprisingly, much of the Lake District is relatively untrammeled. "The problem with the lakes isn't so much that there are too many visitors but that there are too many visitors in too few places," says Chris Bonington, who, as Britain's leading mountain climber, is one of the Lake District's most celebrated residents. We were sitting in his secluded cottage near Caldbeck, in the shadow of High Pike on the park's serene northern fringe.

"Up here we hardly see outsiders from one week to the next," Bonington went on. "There are lots of places that are fantastically beautiful but that most people don't bother to see, usually because they involve a longer, more circuitous drive to get to. Which, I suppose, is lucky for us but unfortunate for them."

A Londoner by birth, Bonington has lived around the lakes since 1974. What drew him to the area, he says, was not just the prospect of climbing on England's highest hills—which are after all mere foothills in world terms—but the peace and

beauty. "It may not be as dramatic as the Alps or Himalaya, but that is in fact what appeals to me," he says simply. "You feel you can be part of it. And I'm continually impressed by the way the human impact on it has been mostly harmonious. The farmhouses, the stone walls, the winding lanes—they all seem to have grown from the land rather than been imposed upon it. There is no place in the world more beautiful."

Again and again in almost a year of poking around the lakes, I encountered people like Bonington who had come as visitors and never left. One such was John Toothill. A quiet, reflective man who relaxes by reading chess magazines in

Doubled by cramps, a young fell runner gets a gentle rubdown after a tough race at Ambleside. Pioneered by farmers and shepherds, fell racing involves lung-busting sprints up mountains, followed by ankle-wrenching descents. "It shatters ye," groans an adult runner.

Russian, Toothill has more the tweedy, cerebral air of a schoolmaster than someone whose passion is the outdoors. His route to the Lake District was typically unconventional. After studying modern languages at Oxford, he worked near London for six years as a junior executive in industry, but on a walking holiday in the Lake District he decided that this was where he wanted to be. Impulsively he took a low-paying post as a clerk with the National Park Authority. That was in 1970. Today he is the park's chief officer.

"The change in the Lake District has been enormous," he told me. "When I first settled here, you often met locals who had only recently got electricity, who had never been out of the lakes, never traveled more than a few miles. You wouldn't find that now."

Back then, too, visitors not only came in smaller numbers but didn't necessarily expect to bring 2,000 pounds of metal with them. Nothing has transformed life in the Lake District like the car. "The trends are terrifying," Toothill says with a

visible shiver. "There are almost three times as many cars in Britain now as there were 30 years ago, and the number is forecast to double again by early in the next century. From the point of view of the lakes' tranquillity, the worst thing that ever happened was the opening of the M6 motorway. It runs just to the east of the park and means that millions more people can reach it."

Ambleside, a small town at the hub of four busy through roads, is already a traffic manager's nightmare. Even in winter an average of 11,000 cars a day nose their way through its narrow, congested streets.

"The day will come when we will have to introduce some sort of traffic rationing," Toothill says, though quite how that might be implemented is more than he can say. "Forty thousand people live inside the park," he notes. "You can't charge them a toll to get to their own homes. And what do you do about all the people visiting relatives or who live just outside the park but want to come in to do some shopping? It isn't a problem that can be answered with tollbooths."

An oft discussed alternative, introducing a park-and-ride system whereby people would leave their cars in parking lots outside the park and be ferried in by bus, is not thought a practical proposition. "Most people will use such a scheme only as a last resort when the park really is full," Toothill says. "The rest of the time it would run at a loss, and no one is prepared to underwrite that cost."

The simple alternative—to try somehow to accommodate all those who want to come by car—he finds even less appealing. "Some people say we should make things easier for the motorist—widen the roads, bypass Ambleside, provide more parking everywhere. But that would attract still more cars, so eventually you would have the same problems but on a much larger scale.

"People don't want to walk to the top of a mountain to get a view of a parking lot. They expect, quite naturally, to find the same sort of tranquil, undisturbed beauty that drew poets to the area. How you give that experience to an ever expanding number of people in a manifestly finite area is the problem we face. I wouldn't say it's impossible, but"—he flashes a hesitant smile—"it's certainly an interesting challenge."

IT IS HARD TO BELIEVE that an area of such rare and potent beauty could ever have failed to attract acclaim, but until about 200 years ago the Lake District was regarded as remote and forbidding, an untamed land at the farthest reaches of England. Novelist Daniel Defoe, on a tour around Britain in the 1720s, dismissed the region as "the wildest, most barren and frightful of any that I have passed over in England."

If any person can be said to be responsible for the special place this Lakeland holds in our affections, it is the poet William Wordsworth, who lived most of his life among the lakes and drew his inspiration from the landscape. It was on a long spring walk around Ullswater in 1802 that he came upon the scene that gave rise to perhaps his most famous lines:

I wandered lonely as a cloud
That floats on high o'er vales and hills,
When all at once I saw a crowd,
A host, of golden daffodils. . . .

As the guiding light of the Romantic movement in English poetry (and not incidentally as the author of one of the first guidebooks to the region), Wordsworth was instrumental in opening people's eyes to an almost mystical correspondence between man and nature, with the Lake District as its apotheosis. He became not just the most influential poet of his age but a kind of tourist attraction himself. His friends and fellow poets Robert Southey and Samuel Taylor Coleridge followed him to the lakes and soon, it seemed, did every writer and artist in Britain.

To Wordsworth's growing despair, the Lakeland became the haunt not only of

Canine competitors bolt after anise-scented bait in the bloodless sport of hound trailing. Trained like athletes, pedigreed dogs fetch hundreds of dollars as pups and can peg 30 miles an hour on open ground. "You've got to teach them to cross roads, fences, and

barbed wire—and not to chase sheep," notes one veteran hound trainer. "Experienced dogs race right by a rabbit without even seeing it." Another tip for hound glory: "Give them a light breakfast of a wee bit of sherry and eggs the morning before."

dilettante artists and poets but also of day-trippers from the industrial cities of northern England drawn by the prospect of fresh air and a skyline undarkened by smokestacks. A new town, Windermere, sprang up to meet their needs for amusements, and ivied mansions, most now transformed into hotels, began to appear along the shorelines of the more popular lakes.

WORDSWORTH spent his eight most productive years in a tiny whitewashed dwelling near Grasmere called Dove Cottage. The seat of the Wordsworth Trust, Dove Cottage has been open to the public since 1891. In its first year it received 422 visitors. Today it gets as many as 15,000 in a month and with its gift shop, tearoom, museum, and other enterprises is Grasmere's main industry.

"Tourists are only a part of what we do here, albeit a large and welcome part," says Robert Woof, an engagingly animated fellow who heads the trust. "Our work also involves the conservation of manuscripts. We have some 30,000 manuscripts in all—including 90 percent of Wordsworth's papers—and the collection is growing by 10 percent a year."

At the moment the collection is housed in a converted barn. "Which, as you might suppose, is not entirely satisfactory," Woof says, showing me into his office, which has the dimensions, and something of the ambience, of a utility closet. "It would be nice to have something a bit more commodious," he says wistfully, "but the difficulty is that even with 80,000 paying visitors a year our resources are stretched thin. We need to renew the air-conditioning, remodel the tearoom and"—his tone grows wistful again—"ideally get it into profit. But, as ever, funds are tight."

In the gift shop I buy a ticket for the cottage. Along with a couple from New Zealand and a party of Japanese, who gamely refuse to let an uncertain grasp of English diminish their enjoyment of the experience, I am given a conducted tour. The cottage is dark and tiny, but throughout Wordsworth's tenure it contained a positive whirlwind of people. It is little wonder that the great man spent so much time tramping the hills. He was a demon walker and thought nothing of walking to Kendal and back—a distance of 33 miles—to borrow a book. His friend Thomas De Quincey calculated that in his long life Wordsworth walked some 180,000 miles.

Inspired by his example, I decided to take up a long-standing offer from an old friend named John Price to go for a walk in the hills. Now the deputy editor of the *Observer* newspaper in London, Price has been coming to the Lake District since he was a boy in nearby Liverpool. He likes to take what he calls ambles over the fells. He suggested we try Bow Fell, at 2,960 feet the sixth highest peak in the lakes. I asked him if it was a hard climb. "Nah, just an amble," he said.

Though it was early on a bleak, cold Saturday in February when we arrived, the parking lots along the narrow, steep-sided valley called Great Langdale were crowded with cars. People sat with the doors open pulling on warm socks and stout boots. There was an air of subdued expectancy and not much talk—no doubt because most, like us, had spent the night before fortifying themselves in a local pub.

We fell in with a straggly army of walkers, all with rucksacks and knee-high woolly socks, and started up a long, grassy humpback hill called The Band. Ahead of us, walkers formed well-spaced dots of slow-moving color that led to an

"I dipped my oars into the silent lake, / And, as I rose upon the stroke, my boat / Went heaving through the water like a swan. . . ." Wordsworth's lines sprang from the stillness of lakes such as Derwent Water, where speedboats are banned today to preserve the muse-like quiet.

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impossibly remote summit, lost in cloud. I was quietly astounded to find that so many people had been seized with the notion that struggling up a mountainside on a damp Saturday in February was fun.

"Is it always like this?" I asked.

"Worse in summer," John said.

We climbed through the grassy lower slopes into ever bleaker terrain, picking our way over rocks and scree, until we were up among the ragged shreds of cloud that hung above the valley floor perhaps a thousand feet below.

The views were sensational—the jagged peaks of the Langdale Pikes rising opposite and crowding against the narrow and gratifyingly remote valley laced with tiny, stone-walled fields, and off to the west a swelling sea of hefty brown hills disappearing in mist and low cloud. But already my legs ached, and the slopes before us looked daunting and vast.

As we pressed on, the weather steadily worsened. The air filled with swirling particles of ice that hit the skin like razor nicks and cut visibility to a few yards. By the time we reached Three Tarns, just short of the summit, the weather was truly

menacing, with thick fog joining the pelting sleet, and ferocious gusts of wind that seemed to rock the hillsides made me stumble and gasp.

When we returned to base four hours later, I was stiff with cold and ached in every movable part, but I was hooked. Walking in the high fells was one of the most wonderful, exhilarating experiences imaginable. In the months to come I did it again and again, though always in better weather and never without aching legs made bearable by a quiet sense of achievement.

The very names of the Lake District hills—Scafell Pike, Helvellyn, Skiddaw, Great Gable—suggest majesty and challenge. It isn't that they are terribly lofty—Scafell Pike, the highest, is just 3,210 feet—but they have a mighty bulk. You often don't realize the overwhelming massiveness of a Lake District hill until you are halfway up it. Then, suddenly, you feel very small indeed. Among much else, the experience left me with a new appreciation of the ceaseless splendor of the Lake District landscape and a profound respect for Joss Naylor.

NATIONAL TRUST

Grand dame of the dales, author Beatrix Potter immortalized Cumbria's rural charms in her Peter Rabbit stories, and she bequeathed 15 local farms to the National Trust on her death in 1943. By Potter's orders, her donated fields continue to feed Herdwick sheep, whose tough coats are traditionally "ruddied up" with dye for livestock shows (opposite).

NAYLOR IS A LEGEND, though you wouldn't suspect it to look at him. Now 57, he is a slight man (pages 6-7), in appearance much like any other farmer in Wasdale Head, the remote and bleakly beautiful corner of the western lakes that has been his lifelong home. But put him in a pair of running shorts and show him to a mountain and he becomes a giant. He is, by common consent, the greatest fell runner of all time.

Fell running—scrambling up and down mountains, often at considerable peril to life and limb—is one of several sports keenly supported in the Lake District and little known outside it. At weekend meetings throughout the summer you can find packs of wiry runners toiling up and over the steepest mountains. To watch a group of young, and sometimes not-so-young, runners take off en masse from a valley floor and within minutes become pinpricks on a distant ridge that took you half a day and many rest breaks to haul yourself up the week before is to arrive at a special appreciation of the Lake District people.

Even in such a group Joss Naylor stands apart. He not only sprints up the most formidable slopes but keeps on going. In 1976, in a feat still spoken of with awe, he ran 108 miles through the Lake District in just under 24 hours, covering 38,000 feet of ascent and descent and scaling 72 summits, all over 2,000 feet in elevation. Much of the run was done by moonlight, all of it over uneven ground. He was 40 years old at the time.

Sitting beside a wall of trophies in the living room of his farmhouse overlooking Wast Water, Naylor merely says, "I was running well that year. Could've done it again the next day with a bite to eat and a few hours sleep."

Naylor has no idea how far he could run in a day on a level, paved surface. Once

he did 134 miles over the notoriously difficult terrain of the Pennine Way, Britain's longest long-distance footpath. "But I was injured for much of it," he adds almost in passing. "Caught my foot in a hole in the ground, and my ankle swelled up like this." He shapes his hands as if about to catch a basketball. "That slowed me down a bit. I probably could have done 170 miles otherwise."

Naylor could assuredly have been one of Britain's great marathon runners but for one thing. He has always had to make a living, and for a hill farmer in the Lake District that isn't easy. Just consider the matter of shearing sheep. At the time of my visit Naylor and other Lake District farmers were getting a penny a kilo for wool, about the amount of wool you'll get off the back of a Herdwick sheep, the hardy but not notably productive stock that grazes the Lake District fells.

Naylor has 1,500 head of sheep. The annual summer shearing involves two to three weeks of intensive, backbreaking labor, and for this hundred or so hours of work he receives all of about $15.

In strictly economic terms, hill farming in much of Lakeland is the wildest folly. Without extensive government subsidies few people could make a living from the land. Selling ewes and lambs brings farmers most of their profits. Like most sheep farmers in the European Union, Naylor was entitled to a subsidy of about $17 for each lamb and breeding ewe in 1993.

But even this is not enough to be competitive with sheep farmers in Britain's lowlands, so the British Ministry of Agriculture provides a top-up subsidy—$4 per ewe in 1993—called a Less Favored Area supplement. In addition, the whole of the Lake District was in 1993 declared an Environmentally Sensitive Area, qualifying its farmers for payments of as much as $143 per hectare (2.5 acres) if they agree to manage the land in an environmentally sensitive way—maintaining hedges and drystone walls, restricting the use of fertilizer, not overgrazing fells, and so on.

Even with these supports, Naylor says he couldn't live adequately on his farm earnings alone. He has a full-time job as a maintenance man at a nearby power station, regularly following an all-night shift at the plant with a full day's work on the farm. Running in such circumstances takes on the air of an indulgence.

Life is not made any easier by being played out in the spotlight of a national park. "Hardly a week goes by that you don't have some authority or other poking his nose into your business," he says in a tone of *(Continued on page 26)*

A WAY OF LIFE ON THE BLOCK

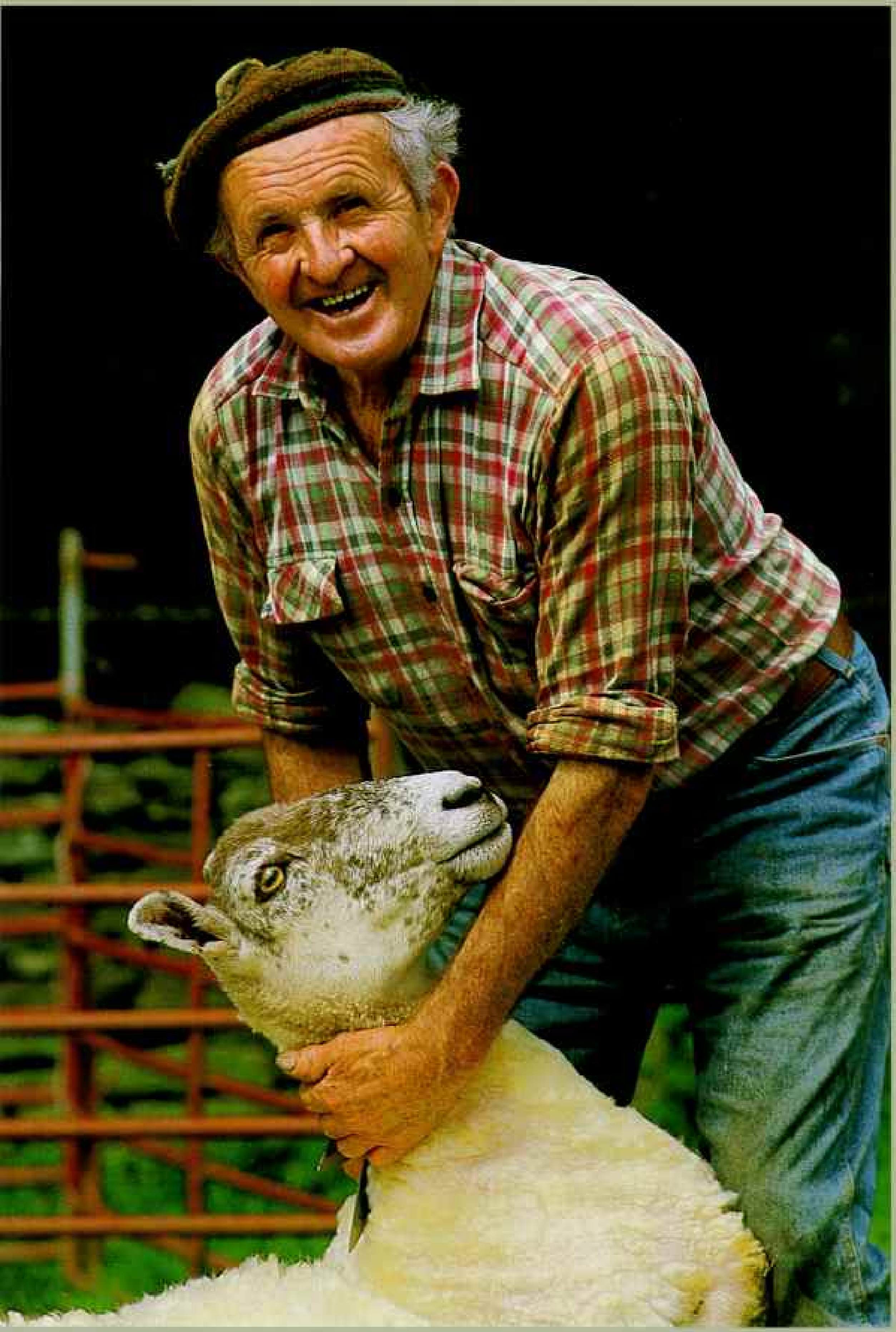
With an auctioneer's singsong dirge (above), another Lake District farmer puts his livestock up for sale. Life is difficult for farmers here, who raise mostly sheep. Herdwick wool brings only a penny a kilo, and prices for lambs are dismal.

Consequently sheep farmers depend on European Union subsidies and government grants for survival. Some diversify by building tourist cottages or renting campsites on their property. Others simply give up.

"When I first came here, there were ten farms—now there are five," says Joe Benn, 65 (right), a jaunty soul who raises cows and sheep on pastureland near the village of Dean. "I'm hangin' on. I'm leavin' my farm to my family."

The trouble is, Benn has no takers. None of his two sons and three daughters are interested in the red tape of subsidy farming—or in tending sheep through Cumbria's bone-piercing winter nights.

"It's been in the family 62 years," Benn says quietly of his cherished 63-acre spread. "Maybe some of the grandchildren will fancy to keep it."



"When will I retire? I'm workin' myself down from 90-hour weeks. Maybe next year it'll be 80 hours."

Among his neighbors, Benn is known as a traditionalist. He worked his land with horses as late as the 1950s. And today he still makes hay (above)—a labor-intensive operation abandoned by younger farmers, who use silage, or fermented grass, for feed.

"I like doin' things the old ways," he says. "But can't do them like I used to."

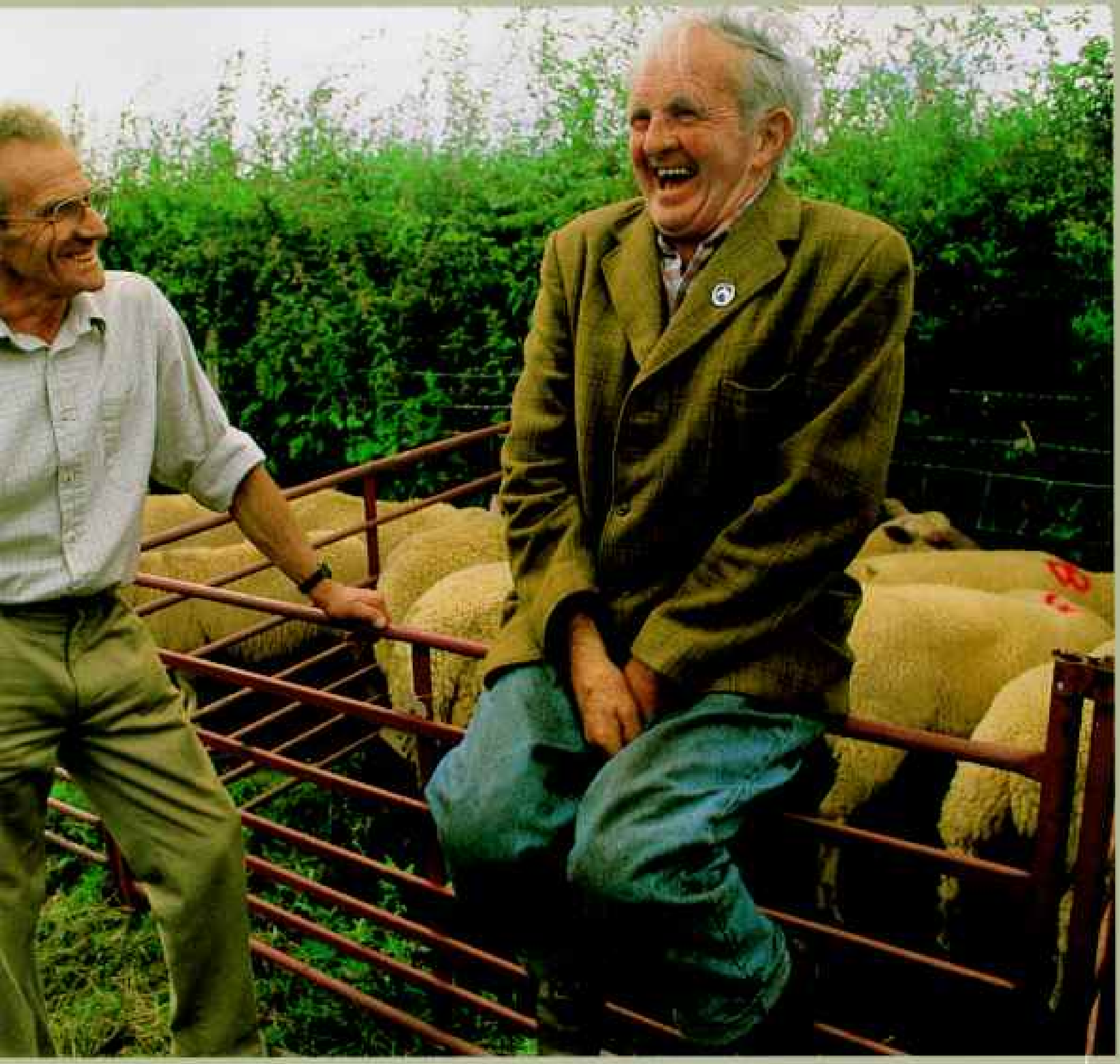
Two reminders of change recently interrupted the endless routine of moving of sheep over the green fields of Cumbria. He celebrated the christening of his youngest granddaughter, Sophie, in his 18th-century farmhouse (right). And his friend of nearly 50 years, Billy Taylor (top right, at left), heard the siren call of the auctioneer. Benn bought some lambs from his friend—a contribution to his nest egg.

"Billy Taylor is doin' OK in retirement," Benn muses. "He's got rid of a lot of the pressures of life."

So, what about him?

"When will I retire? I'm workin' myself down from 90-hour weeks. Maybe next year it'll be 80 hours."

His wife, Margaret, overhears this vow and laughs in loud, merry disbelief.



(Continued from page 21) long-suffering forbearance. "Neighbor of mine not long ago had some naturalists 'discover' a rare patch of wildflowers on his land. They told him that on no account should he spray it with fertilizer because it would ruin the flowers, which surprised him because he'd been spraying it for 25 years. So he stopped, and the next thing you know the wildflowers are all gone. The sheep, you see, got interested in that patch of ground because it didn't have fertilizer on it and cleared every bit of it. These college folk may know flowers, but they don't know sheep."

COMPLAINING about the muddled interventions of outsiders is something of a tradition among Lakeland farmers. At his cottage in Torver, Arnold Lancaster showed me a boxful of documents he had accumulated since becoming involved with something called the Torver and Blawith Commons Draft Management Plan.

"It's to do with managing the common land, but just look at it," he said, and began tossing onto the table in front of me reports, documents, and proposals that had been submitted to the Ministry of Agriculture by interested parties—English Nature, the Cumbria County Council, the Center of European Agricultural Studies, the Agricultural Development and Advisory Service, and at least a dozen other bodies, all with proposals on how these 150 acres of high fell could best be managed. "We've had meetings and more meetings. We've had meetings about meetings. There's no end to it, and all over a bit of common land that was working fine in the first place."

Between the economic uncertainty of farming and the exasperations brought on by conservation groups, tourists, and bureaucrats, more and more farmers are calling it a day. As farmer Joe Benn says, "You've always had to be a jack-of-all-trades in this business—farmer, waller, joiner, vet, shepherd, but nowadays you practically have to be a bloody lawyer as well." The number of full-time farmers in the Lake District declined by 8 percent in the 1980s, and the trend is implacably downward. "A farmer can sell his property," notes John Toothill, "bank the proceeds, and live far more comfortably off the interest than he can by chasing after Herdwick sheep in all weather. You can hardly blame them."

The problem is that the person who buys the farm will more likely than not be a well-heeled urbanite who wants the house for a vacation home but has no particular interest in managing the land. Since the 1960s hundreds of outsiders have bought houses, cottages, and farms all over the Lake District to use as second homes, driving prices beyond the range of what many locals can afford. It is a source of perennial resentment.

"We've tried at various times to alleviate the problem," a planning official told me. "At Chapel Stile we approved the construction of 21 low-cost houses for locals in the late 1960s. It's a frankly hideous development. It would have been too expensive to build traditional stone-and-slate cottages as we would have liked, but we felt that cheap housing was better than none. And it was—for a while. But the last time I counted, 18 of those 21 properties were holiday homes. So we now have a permanent blot on the landscape that is of practically no benefit to the locals. What can you do?"

The increasingly high cost of Lakeland homes has not only effectively banished many locals to cheaper outlying areas but also robbed villages of much of their life. Many communities are half empty through the winter. "Twenty years ago there were 43 children in this village," says Arnold Lancaster of Torver. "We used to have an annual party for them, with a parade and ice cream and all that. Now there are just three kids. You can't have a parade for three children."

Simmering resentment against offcomers, as they are known, was something I encountered often. One farmer told me: "I had an offcomer banging on door t' other day complaining that my rooster was waking him up of a morning. I

explained to him that that's what roosters do. You get 'em complaining about dogs barking, cows nibbling their shrubs, about almost anything that's different from city life, and you wonder, well, if you don't like the country, why on earth did you buy a place in it?"

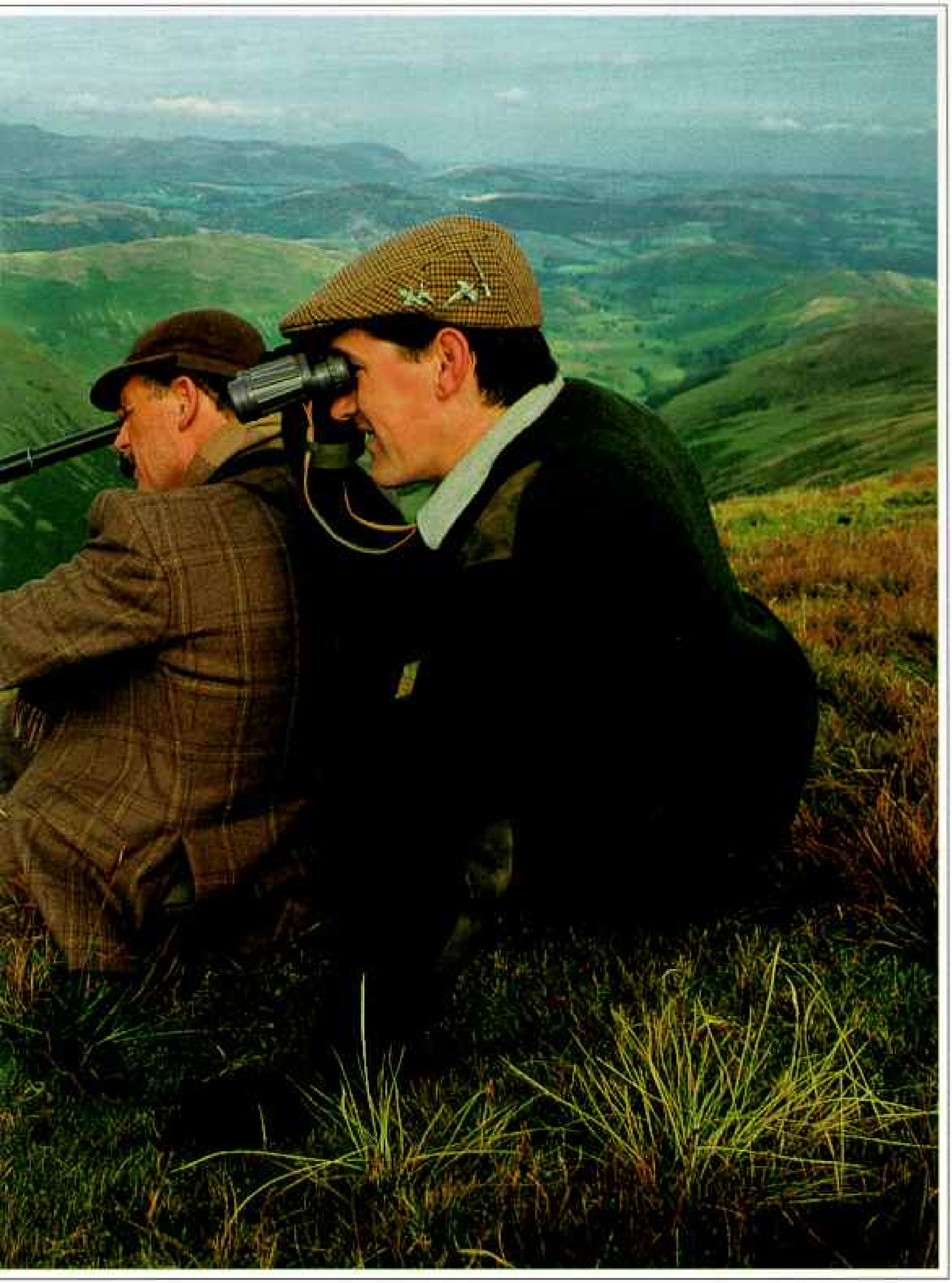
It's all a far cry from the Lake District that Beatrix Potter knew and adored early this century. At Hill Top, her bucolic hideaway in Near Sawrey, Potter created Peter Rabbit, Pigling Bland, Mrs. Tittlemouse, and dozens of other venerable children's story characters and used the considerable wealth it brought her to buy farms and other properties in the lakes in the hopes of saving them from

Endangered in England, a barn owl gets royal treatment at the Owl Centre, which breeds and releases the birds into the wild. Intensive farming has destroyed the habitat of the owls' main prey—short-tailed voles. "Only 2,000 pairs of birds remain," laments center director Tony Warburton.

overdevelopment. At her death in 1943 she left 15 farms as well as other properties to the National Trust, a charitable conservation body. Potter left the trust some 4,000 acres in all. Her husband left a further seven properties. Between them their bequests increased the National Trust's holdings by half and helped set in motion the drive to preserve this delicate landscape, which eventually led to the creation of the national park in 1951.

"We work together with the national park since our interests are very much the same—to keep the Lake District beautiful and to help visitors enjoy the experience," Oliver Maurice, head of the National Trust in the Lake District, told me. "But we are two quite separate bodies. They are a government agency; we are a private charity." The National Park Authority is responsible for the upkeep and well-being of the whole park. The National Trust, on the other hand, is responsible only for those parts of it that it owns. In practice, since it employs its own wardens to manage its estates and assist the public, it takes on the day-to-day

"You see them on the skyline—usually running away," says professional game stalker Gregor Cattanach, at left, who leads clients such as Kirk Robertson on guided deer hunts at Lowther Estates. The 76,000-acre property manages a herd of 800 red deer—



an elegantly antlered species native to England. "We do it all traditional," Cattanach says of his efforts to track the shy animals. "We've been known to crawl 300 or 400 yards. It's a workout. Clients can get absolutely whacked."

Mugging for handouts, swans resort to strong-beak tactics on the Bowness waterfront. Though some may mourn a more placid past, the Lake District's special magic persists, if only because it can't be parceled out—the clean taste of morning fog, the bowl of space above a summer valley.

responsibility for a large portion of the park. The trust owns 85 farms, plus fells, lakes, and tarns—140,000 acres in all, about a quarter of the total area of the Lake District—as well as gardens, a castle, and a scattering of holiday cottages.

Amid all this Hill Top is a small but disproportionately important part. I went to see it one bright summer morning. It isn't hard to find. Three full buses had arrived, and there was a procession of cars in and out of the two parking lots discreetly tucked away nearby. The trust gives it very little publicity—for a time it gave it no publicity at all—and in 1992 tried to thin the crowds by moving Potter's delicate watercolors to a gallery in Hawkshead. But still the visitors pour in.

"We get 70,000 visitors a year at Hill Top and expect the figure to rise to 120,000 by the end of the decade," says Oliver Maurice. "That is obviously a great deal more than any house is designed to handle. Much of what we do is invisible. People don't notice things like footpaths and walls. They think they magically appear and somehow maintain themselves. What they don't appreciate is that it all costs an enormous amount of money. We spend 3.5 million pounds [2.4 million dollars U. S.] a year just to stand still."

AT THE NATIONAL PARK HEADQUARTERS in Kendal, John Toothill is equally worried by the perception that the Lake District landscape is somehow effortlessly timeless. "I worry about trees," he told me. "Most of the woodland trees you see were planted in the late 19th century. In the next 40 or 50 years they're going to start dying off. Unless we start replacing them now, the dales are going to be very much barer by the middle of the next century."

Unfortunately, tree planting on any but the most modest scale is a luxury he cannot afford. Toothill's total annual budget, including money generated internally from parking lot charges and other fees, is 3.7 million dollars. From that he must manage the park, run ten information centers, pay 127 full-time staff (plus an additional 40 in summer), implement educational programs, maintain equipment and vehicles, fund improvements to the landscape, *and* act as the local planning authority. Almost any new development in the park, from a proposed shopping center at Ambleside to something as small as a homeowner wanting to put new windows in a Georgian terrace house in Keswick, must be approved by national park staff. It all takes money.

Despite the manifold pressures, Toothill is not a gloomy man. "Oh no," he says without hesitation when I ask if he finds the job discouraging. "One thing you learn is just how passionately people feel about the lakes. Do you know, our 350 volunteer wardens work hundreds of hours a year without a penny of pay. They do it for the love of it. We get so many offers of voluntary help that we can't accept them all. We just haven't got the resources to equip and supervise them. I think that is *terribly* heartening."

He shifts forward in his seat and shows a measure of passion of his own. "Millions of people come here every year—more than to almost any other national park in the world—and still manage to find a countryside that is largely unspoiled and often incomparably beautiful. We have problems, certainly, but they are the problems of success."

It is a thought that stayed with me when I made a second, farewell ascent up Bow Fell. It was a fine September Saturday, and the walkers were even more numerous than they had been when I had walked it seven months earlier.

When I reached the summit, I counted 34 other people. They sat mostly in groups of twos or threes, eating packed lunches, studying maps, or quietly talking about felltop adventures. A few nodded to me, as if welcoming me to a select club. I found a perch and sat with my sandwiches, grateful to rest my weary legs. There was, I noticed, a kind of lazy, unspoken camaraderie among us. As I ate, more walkers arrived, looking flushed but quietly exhilarated. With a nod, I enrolled them in our little club.

It occurred to me that it is like this through all seasons on Bow Fell—people hiking to the top, savoring the experience for a time, then quietly drifting off to be replaced by fresh arrivals. It has been this way for decades and will be for decades to come. I liked that very much—the idea that you can have an experience you share with millions and yet is also somehow profoundly personal and special. That, I decided, is the special enchantment of the Lake District.

I packed up my things, hoisted my rucksack onto my back, and took in the view across the sea of hills one last time. Then I turned and with a light heart began the long trudge down the hill. □

LIONS
OF DARKNESS

Terror is more often heard than seen in the African night. But patience and skill have enabled Beverly and Dereck Joubert to capture remarkable images of lions hunting in the dark in Botswana. Some are shocking—a lioness sinks her teeth into a petrified young elephant (right). Or surreal, like a maelstrom of doves at a dwindling water hole shared tensely by elephants and hungry lions (preceding pages). These particular cats attack very large prey, leading to confrontations compelling to the ear, and to the eye.

By DERECK JOUBERT

Photographs by BEVERLY JOUBERT

BATHED IN THE LIGHT of a nearly full moon, ten lions slept peacefully, sprawled together in the grassland. Around them in the night, zebras, antelope, and other potential prey moved through the savanna, but the lions had chosen not to hunt them. It was nearly midnight. Suddenly the moonlight disappeared.

A few yards away in our four-wheel-drive vehicle, we gazed up and saw that clouds had engulfed the moon. Lightning split the African sky and a blast of thunder startled both us and the lions. Pelted by a wind-whipped deluge, we struggled with canvas in a vain attempt to keep our vehicle dry. The lions huddled miserably together, their fur dripping.

But when it was over, a silver lining remained for the lions—a cloak of clouds. In near-total darkness, with no bright moonlight to reveal their presence, the lions swung into action. The hunt was on.

Whenever Beverly briefly turned on our filming lights, zebra eyes shone back. Of the lions, we could see only one female that slipped silently past us, circling. Then our ears picked up the chase—hoofs smashing into the wet earth as zebras fled for their lives. At last came the sounds we were straining to hear—a thud and a wheeze as a lion slammed into a zebra, knocking the wind out of it as it fell. After the kill, the pride began to feed and paid no attention as Beverly turned on the lights to record the scene.

A midnight storm that clouds the moon is a bit unusual, but it illuminated one of the hunting techniques of lions in northern Botswana's 4,080-square-mile Chobe National Park. For 13 years, with the cooperation of Botswana's Department of Wildlife and National Parks, we have followed the lions in one very prolific area of the park known as Savuti.

Here lies a wide-angle window into the continent's primeval past. Natural rhythms of seasonal rains spark migrations as animals follow a dwindling water supply. Covering 200 square miles, Savuti attracts wildlife in spectacular numbers, with some 460 species in all, including 32 species larger than a jackal. Many are important prey for lions.

Our task was to research, record, film, and photograph every aspect of lion behavior. But how to do it at night, when the lions are most active? They are seen only by day, mainly by the hundreds of tourists who stop in Savuti each year as they travel from the Okavango Delta, just to the southwest, to Victoria Falls in the north.

In the past most lion researchers limited their work to daylight observation. Our challenge was to devise a means of witnessing lions' nocturnal tactics without interfering with either the predators or their prey. Very gradually we developed a way to accustom the lions to our vehicle and our filming lights. We also adopted a set of rules for ourselves that emphasized noninterference.

We spent weeks introducing the lions to artificial light, beginning with just a flashlight beam. To do the filming, we use lights modified with special batteries so that their intensity is equivalent to 100 watts—similar to our vehicle's headlights in the bright mode.

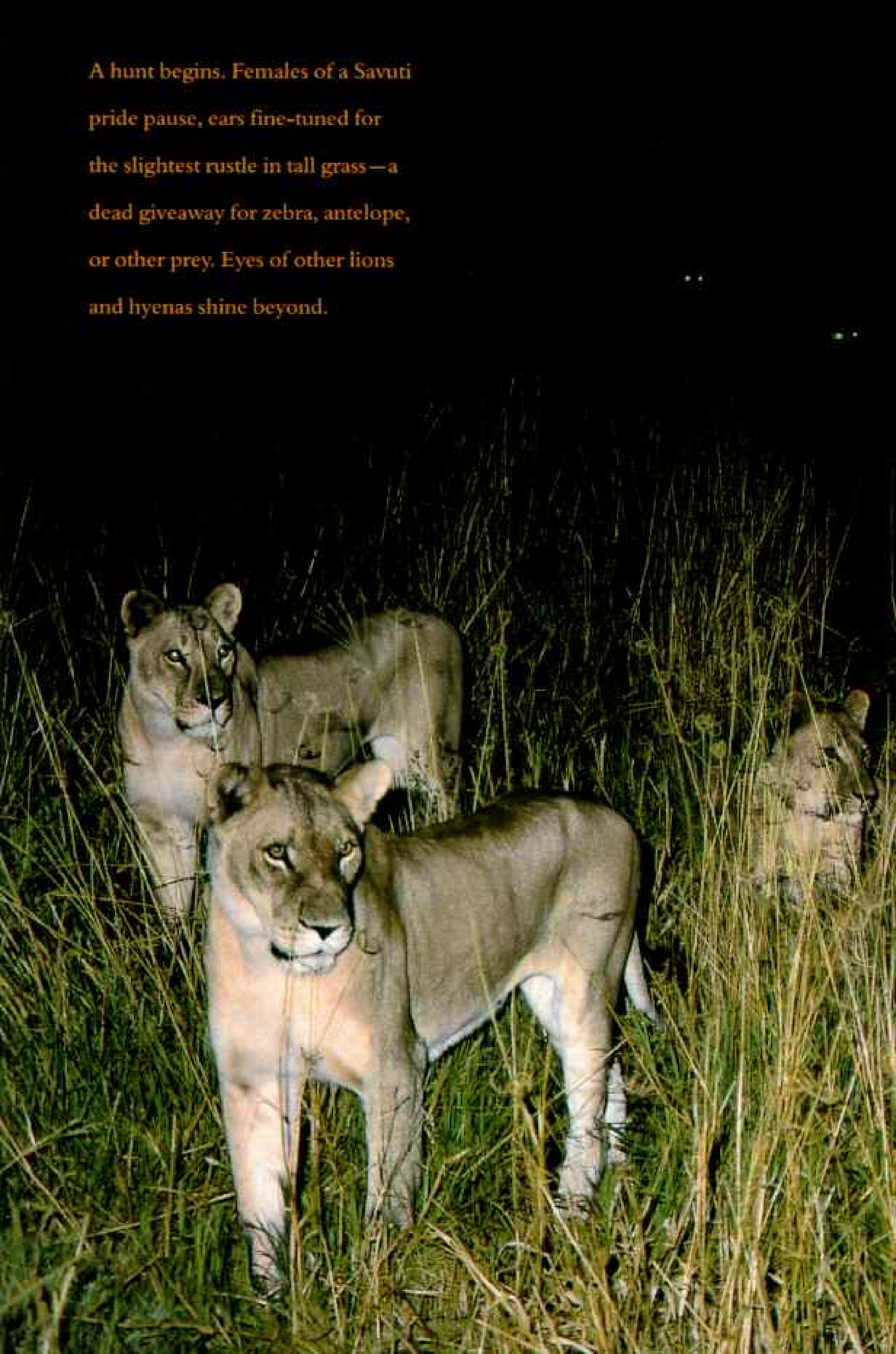
We never turn on the lights during the initial chase, only after the lions have zeroed in on their quarry or are already feeding on the kill. To follow their actions, we keep the lights off whenever possible and use special night-vision equipment that intensifies images. We had parts of our vehicle rubberized to minimize creaks and groans, and we always maintain a minimum distance of 150 feet from hunting lions.

Eventually our patience paid off, and a new world opened to us. Nearly every night we were able to follow the lions on their hunts and stay out all night with them. With each passing sunset we realized that by dawn our

DERECK and BEVERLY JOUBERT, a husband-and-wife team of naturalist-cinematographers, have filmed northern Botswana's wildlife for more than a decade.

Felled in the 1992 fall migration, a zebra foal will feed a male the Jouberts named Mandevu. In only ten days, lions and hyenas killed some 150 migrating zebras in Savuti, part of Chobe National Park.

A hunt begins. Females of a Savuti pride pause, ears fine-tuned for the slightest rustle in tall grass—a dead giveaway for zebra, antelope, or other prey. Eyes of other lions and hyenas shine beyond.



lives would be different, enriched by a new experience.

In Savuti we have identified approximately 120 individual lions in six different prides, using field marks such as scars, ear nicks, and whisker-spot patterns. We have spent much of our time with one pride named for a female, Maome. All told, we have logged more than 24,000 hours of observation, and we have witnessed more than 4,750 hunts, 1,300 of them successful kills.

Our observations have led us to conclude that the rhythm of the moon is very important to the lions' hunting. Only 5 percent of the kills we observed occurred during daylight. Of the kills that took place at night, 85 percent occurred when the moon was less than half full, or when it was below the horizon.

These Savuti lions have learned that too much moonlight makes their hunting less successful. Perhaps they become too visible to their prey; other unknown factors may also be involved. Overall, they make a successful kill in only one of every four attempts.

The open grasslands are their preferred hunting grounds, where 70 percent of the kills we witnessed were made. Occasionally, when the moon was too bright and the lions failed too frequently, they would disappear into the neighboring woodland, where dappled shadows of acacia and mopani trees camouflaged them. There they found the same prey as in the grasslands, but the hunting was more productive than in the bright moonlight.

Often we dozed with a pride until the moon dipped below the horizon. A small, sudden temperature drop around 2:30 a.m. usually seemed to rouse them. Then they rose, yawning and stretching, as they began to search for the new day's first meal. That they choose the coolest hours to hunt serves as an energy conservation measure, for lions have relatively small hearts that cannot withstand the demands of a long chase in the heat of the day.

While the effect of the moon on the lions was a dramatic

Before moonrise, Mandevu and a female close in on an impala; Mandevu makes the kill. Lions avoided hunting in bright moonlight during 85 percent of the night kills the Jouberts witnessed.

revelation to us, we also found that these lions sometimes behave differently from other African lions. They routinely attack powerful prey such as Cape buffalo, young elephants, even hippopotamuses. With our cameras, we were able to unveil from the night many of their dramatic hunts.

Piling on gently, a young lioness rolls on her two brothers. They had just killed a wildebeest and fought over the meat; now they're sociable again.

THE LIONS became totally at ease with our ragtag vehicle—its doors and roof removed to accommodate tripods and to allow easy exit in an emergency. Its frame has been bashed by elephants. It once nearly carried us into the hereafter when we followed lions across a small brush fire. Picking our way over glowing red coals was eerie, like driving on Mars. Suddenly we looked at each other—we both smelled fuel. I hit the brakes, luckily stopping in an area free of flames and coals. A stump had disconnected the gas line in the undercarriage. We fixed it and drove on.

We have known these lions since 1981. We often awake to find Maome's pride sleeping around our vehicle, one lion's head propped up against a tire, as they wait for the moonlight to dim. The pride currently includes seven lionesses, plus two mature males that are semi-permanent members. Maome is easy to identify. She is missing the last four inches of her tail, an unmistakable field mark. Motsumi, a big lioness, bears large scars on her back. We have followed her since she was three weeks old and witnessed crises such as her cubs' death—and nearly her own—from a cobra attack.

Some lions had been named by previous researchers, and some, like Motsumi and Mandevu, one of the males, we named. The other male is

Ntwadumela, a formidable mouthful for a forceful lion. In the Setswana language it means "he who greets with fire." He was named this because when his quarry is in sight, Ntwadumela never hesitates. The popular notion that only lionesses kill prey is wrong; male lions do hunt successfully.

Maome's pride led us on many extraordinary hunts, including several confrontations at water holes. For lions, prey becomes scarce after the rains end in May. Savuti's 5,000 impalas and 2,000 tsessebe antelope are always available, but these two species will not sustain the region's lions for long.

Elephants dominate the dwindling pools. But because they and the lions are sharing such a small space, the lions seem to lose the natural wariness they have for the much larger animals. Three lionesses in Maome's pride—including Motsumi—specialize in attacking elephants. We have seen such specialization take many forms, with some lions adept at killing giraffes, others preferring warthogs, still others expert with tsessebes.

One night, after a crescent moon slipped below the horizon about nine o'clock, Motsumi and two other lions stalked prey at a water hole. In our vehicle, we hung back, lights off, using our image intensifier to watch Maome, who stayed back with us. Maome is not usually in the advance guard of elephant-hunting lions; but she was watching every move they made, and her reactions told us a lot.

Then we heard the other lions running, and the bellow of a young elephant. About four years old, the youngster had become separated from its herd and was now in danger. Maome flew like a dart toward the elephant's cry, as we followed. We switched on the lights just as Motsumi leaped on the elephant's back and bit into its spine.

It was a gripping sight—300 pounds of lion versus a ton of terrified elephant.

Following Maome's lead, four more lions hurled themselves into the fray. Soon the doomed elephant was draped with

(Continued on page 50)

The Face-off

Outweighed six to one, a lioness confronts 1,800 pounds of mean, grizzled Cape buffalo bull. Her pride of six lions had cornered the bull near the Jouberts' camp. The lions were young, and none had yet mastered the tactics of hunting buffalo. For them, graduate school was about to begin.

Launching the attack, one lioness leaps on the bull's back and bites into his spine. Her quarry then bellowed desperately and spun back and forth, trying to shake off his antagonist. The other lions kept the bull boxed in, circling around to attack from the rear and nimbly leaping to avoid the murderous arc of the bull's massive horns.

In a cloud of dust some four hours later, the bull's tormentors finally haul him down and fasten their teeth onto his throat to suffocate him. Buffalo-hunting lions pay a price; their foe's kicks can fracture ribs or a skull, and horns can rip open a hip. Yet these lions go out of their way to attack buffalo—for reasons unknown.

Eternal enemies: Badly outnumbered, a lioness is menaced by hyenas. In Savuti this rivalry is constant and can be fatal to both animals.

tawny attackers and keeled over. Death came with agonizing slowness. Lions usually kill by strangling or suffocating their prey, but when the elephant's attackers clamped their jaws onto its mouth and throat, their victim could still breathe through its trunk. Not until an hour and half later did the elephant succumb. Although we have seen many of Africa's predators play out their roles again and again, some kills are more difficult than others for us to watch. This was one.

It was the first of several elephant kills we were able to film. During the dry season Savuti's lions depend heavily on elephants for food. In 1990 Maome's pride ate elephant so often that the meat accounted for 20 percent of the diet, we estimated, although much of that meat was scavenged from animals that had died of natural causes. Finding vulnerable elephants is no easy task, for although some 50,000 range northern Botswana, the lions' territory is very small, and they probably have only a few dozen elephants within range at any given time.

WHEN we set up our current main camp on the edge of Zibadianja Lagoon west of Chobe, we became acquainted with a new pride. Three young males and three young females began to visit us every two or three nights. We named them the camp pride.

This pride often reminds us that although lions make their living by tearing meat apart, they are also very social animals and very playful. They love to ransack the gear in our camp. I often end the day by attaching

frying pans, lanterns, and other gear to a cable, then hanging it higher than a lion could reach. But nothing really helps. Once they knocked down our solar panel, tugged on an electrical wire with me on the other end, and overturned an open 44-gallon drum of fuel.

The lions are not our only companions. At night we are often soothed by the gentle sound of hippos methodically crunching away as they feed on the short grass. We thought it likely that the lions would take no notice of the hippos—after all, the hippos can throw two tons of weight around.

But one night just after the moon had set, the camp pride awoke and moved around the edge of the lake. Then they ran straight into a group of about ten hippos—which soon became very agitated hippos. The lions leaped on the backs of several adults feeding at the water's edge. Roaring, the hippos tried to twist their heads, apparently to bite their tormentors. When that failed, they plowed toward the safety of deep water, splashing thunderously.

Once the hippos reached deeper water, the lions jumped off and swam to shore. Amid the chaos, they eventually managed to isolate a young hippo in shallow water. They knocked it down, flipped it on its back, and finally dragged it onto the grass. The little hippo proved difficult to kill. Its throat contained so much fat that the lions had a hard time inflicting the fatal throat bite. One male lion took a nasty kick in the face.

Elephants and hippos are difficult challenges for these lions, but another animal may be even more formidable—the Cape buffalo. Several hundred roam the area. The reputation of these aggressive, unpredictable beasts is legendary. Declared one experienced big-game hunter, William Judd, around 1900: "I consider them far and away the most dangerous game. The difficulty of stopping a direct charge . . . the way they can force themselves through bush absolutely impenetrable to man . . . make them an adversary worthy of the greatest respect."

Yet Cape buffalo are among the favorite quarry of the region's lions. While elsewhere in Africa lions are known to tackle and bring down Cape buffalo only occasionally, these cats will actually go out of their way to do so.

Once we were following lions that had been stalking giraffes for about two hours. When they heard a distant buffalo, they abruptly broke off the hunt and immediately switched targets.

Why? With those long legs, giraffes can run very fast without tiring. We witnessed about 200 giraffe hunts by lions, and only six of them were successful. Of roughly the same number of buffalo hunts we saw, only three failed.

SHADOWING the hunters in the night are the lions' ancient rivals, the hyenas. For three years we suspended our work on lion predation to study this relationship intensely. We found that in Savuti there are differences in the ways lions and hyenas interact compared with elsewhere in Africa.

Much confusion has existed about each animal's role. It was long believed that lions were purely hunters and hyenas purely scavengers. The lines began to blur when it was observed by biologists, including Hans Kruuk and George B. Schaller, that lions sometimes steal carcasses from hyenas.

In Savuti the behavior of both animals spans the spectrum. Lions and hyenas are skilled hunters in their own right, and each species steals kills from the other.

But to us the most important thing is the constant conflict between lions and hyenas. Although disputes sometimes arise over competition for food, they often spring out of pure aggression. In Savuti this may be heightened by high densities of both animals.

We have often seen hyenas inflict vicious wounds on a lioness that has become separated from her pride, with no kill present to quarrel over. And lions will deliberately hunt down hyenas and kill them without bothering to feed on the remains. Twice we have seen Ntwadumela charge directly into a hyena clan and kill the ruling female.

One day the lions win. The next, the hyenas. Why? After watching a skirmish, I wondered if the outcome of individual battles could be predicted. Could the combined weight of each side be the determining factor? A pride of Savuti lions comprises about ten animals, while a hyena clan varies between 18 and 40. An adult lioness weighs approximately 300 pounds and a hyena as much as 175 pounds. But in a clash, each side is rarely at full strength. For various reasons, there are always absentees.

From our field notes I totaled the number and weight of all the contestants on each side in the battles we had witnessed. The results supported my theory.

If an entire pride of lions met up with a full clan of hyenas, the combined weights were so even that the outcome could not be predicted. But some members were always missing, and that tipped the balance. The side with fewer absentees—the heavier side—always won.

We remember one particularly exhausting evening. It started, as always, at sunset, as vehicles full of tourists departing for their camp pulled away from the sleeping lions of Maome's pride.

For us, work began. The pride awoke and throughout the night led us on a grueling chase as they made a series of kills. First they downed a small hare, then a young zebra; then they fought a three-hour marathon to kill a buffalo.

As the lions began their buffalo feast, they were charged by a clan of hyenas. Badly outnumbered, the lions abandoned their hard-won meal and climbed the dead trees nearby. We had followed the lions for 11 hours, zigging and zagging for 45 miles through the Savuti grassland. Now we stayed until the horizon turned orange and we could see the lions' silhouettes against the dawn.

With the hyenas gone, the pride eventually came down and walked over to the little fringe of trees that promised the only shade during the heat of the day. They chose their favorite tree and lay down.

Soon, the first tourist vehicle pulled up, bringing visitors who had been there the day before. "These lazy lions haven't done a thing since we left," one remarked in disgust.

We were just too tired to correct him. □

National Geographic EXPLORER will air "Lions of Darkness" in two parts, on August 21 and 28 at 9 p.m. ET on TBS Superstation.

At daybreak a long night of hunting ends for Ntwadumela and his pride. Now Savuti's lions will curl up in the shade, awaiting sunset and the darkness that they rule.

NASA PUTS THE "CAN DO" PROJECT IN ORBIT

Students With a Mission

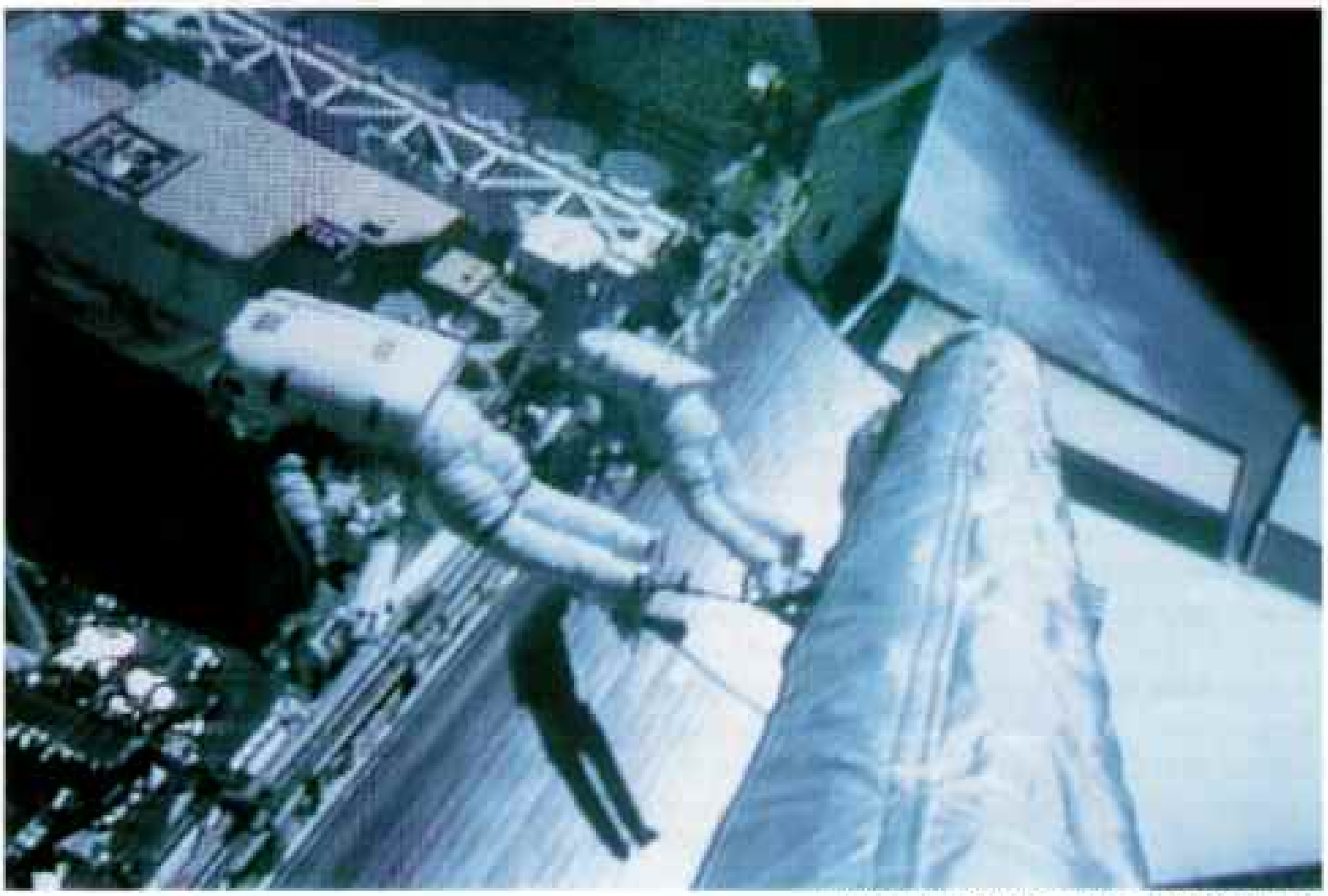


IMAGE SCIENCES DIVISION, JOHNSON SPACE CENTER, NASA

By JAMES H. NICHOLSON Photographs by IRA BLOCK

Even before there were astronauts, youngsters dreamed of looking homeward through the blackness of space, of seeing earth hanging below like a great turquoise blue pendant.

The dream came true last summer for students in Charleston County, South Carolina. After ten years of planning, hoping, and heartbreak, they launched their own payload on the space shuttle *Endeavour*.

Their scientific package: four cameras, along with 261 test tubes filled with samples ranging from Alka-Seltzer to human hair. All were loaded in a canister dubbed CAN DO (above, the brightest container in the shuttle's open cargo bay, just beyond the head of the astronaut at rear).

As earnest as any NASA scientists, students like 11-year-old Katherine Douglas (right) used weather and orbital data to decide what earth features to photograph with the CAN DO camera assembly, which the students dubbed GEOCAM.

"I can never be an astronaut because my eyes are really bad," says Katherine. "But now I'll always be able to say I worked with


EDT
MET

High hopes

"I'm living a dream," said teary-eyed teacher Ruth Ashcraft-Truluck (below), watching the space shuttle *Endeavour* rise from an unusually dry Kennedy Space Center in Florida (right). She'd worked on the CAN DO project since 1984. Getting VIP treatment, Charleston County students saw shuttle *Discovery* being prepared for a later launch (above).

shuttle astronauts and helped out NASA."

Amid the din of their mission control center at the Medical University of South Carolina in Charleston, the students directed GEOCAM's operations, using headphones to communicate with one another and with the Johnson Space Center in Houston.

Standing in the CAN DO control room as the project's technical coordinator, I realized that I had been working toward this day since before many of the youngsters involved were born.

Early in 1984 the Charleston County School District got the opportunity to launch a student-run science experiment aboard a future shuttle. The project would have to fit inside one of the shuttle's Get Away Special canisters—also known as GAS cans—which NASA makes available for educational, government, and research use. The plan was to take pictures from orbit. Armed

JAMES H. NICHOLSON is an imaging specialist at the Medical University of South Carolina. Free-lance photographer IRA BLOCK's most recent foray into aviation for NATIONAL GEOGRAPHIC was "The Wings of War" (March 1994).

ANTHONY PERITORE, MSS STAFF, AND JON SCHNEEBERGER (RIGHT)

JOHNSON SPACE CENTER, NASA

Kids in control

Mission control in Charleston (right) hummed for *Endeavour*'s ten-day mission as students directed GEOCAM, the photography portion of CAN DO's payload.

Elementary school students watched the weather, using satellite images provided by NASA. Their job was critical: Photo targets had to be set a day ahead of time, so the students had to predict if a given region would have clear skies 24 hours later.

Middle school students worked as targeters, deciding which landforms along the orbital path would make interesting photo subjects.

Besides occasionally helping younger kids with the weather, high schoolers monitored shuttle crew activity to determine when astronauts might be available to trigger the cameras.

GEOCAM's operations—and the opening of its motorized lid (left)—were controlled with a keypad, held by astronaut Nancy Sherlock (below right).

with scientific imaging experience, my colleague Tom O'Brien and I eagerly joined the team that designed and built the payload. The school district had no shortage of teachers enthusiastic about the project. After all, grown-ups have dreams too.

With little money and even less space experience, we went to work. Launch date was set for March 1986.

Then *Challenger* exploded. The shuttle program halted for nearly three years, but Charleston's students remained determined to have their day in space. That day came on June 21, 1993, when *Endeavour* roared into the Florida sky. With it soared CAN DO and the hopes of thousands of students.

Virtually every photograph of earth previously taken from the shuttle had been shot through the spacecraft's thick windows, designed more for safety than for optical clarity. Flying upside down, with its bay doors open, the shuttle became a perfect platform for GEOCAM's lenses, aimed through a specially ground optical window in the top of our CAN DO canister.

For ten days after the payload was launched, the students were truly in charge of the best combined science project and geography lesson ever. As elementary school teacher Beth Anthony told me, "The room was filled with that special music that only a seasoned teacher would fully appreciate: that beautiful hum of busy young minds working together."


CAN DO
CDT
EDT
CAN DO PROJECT
GEOCAM
Mission Control Room
Staff
CAN DO
GEOCAM


CAN DO
GEOCAM

Adult assembly required

Begged and borrowed, components of the CAN DO project were assembled by engineer Tom O'Brien in a clean room at the Goddard Space Flight Center in Greenbelt, Maryland. Cameras were provided by the National Geographic Society; other parts were manufacturers' surplus.

SUSAN BRIMBERG (LEFT); NASA/CHARLESTON COUNTY SCHOOL DISTRICT

The Congo Basin

Clouds usually veil the Zaire River and its tributaries in the Congo Basin. On a rare clear day *Endeavour*'s crew shot this 300-mile mosaic—the Congo republic on the left bank, Zaire on the right—with GEOCAM. Dark areas are vegetation.

Window on the world

Following a typical space shuttle orbital pattern, *Endeavour*'s equator-crossing path ruled out photographs of the GEOCAM team's home base in Charleston but gave plenty of chances over parts of five continents. Shooting through a specially ground window, GEOCAM used high-definition black-and-white film to ensure the sharpest possible images. So impressed was NASA that it will use the same type of film on future shuttles.

NASA/CHARLESTON COUNTY SCHOOL DISTRICT (LEFT)

Grand opening

Christmas came in July for the author (top, at right) and O'Brien as they opened the lid of CAN DO at the Kennedy Space Center after its return from space.

Project intern Summer Sparkman and 12th grader Adrian Nida (above) unloaded CAN DO's aluminum box of vials containing student experiments in the project's technical facility—Tom O'Brien's home workshop.

GEOCAM's crystal-clear image of southwestern Africa's Skeleton Coast (left) "could be a gold mine in terms of scientific research," says Pat Jacobberger Jellison of the Smithsonian's Center for Earth and Planetary Studies. A GEOCAM image will go on display at the National Air and Space Museum this year.

BENICE SMITH, BRICE MARINE BIOLOGICAL LABORATORY, COLLEGE OF CHARLESTON

Down-to-earth science

The space-age science project began with Wando High School students scraping lichens off tombstones in a Civil War-era cemetery (top left). Filtering water through the lichens (center), the students flushed out microscopic tardigrades, also called water bears (left). The animals can live for years in suspended animation if dried out. They begin to revive in minutes when rehydrated.

Dried water bears were taken into space in one of hundreds of

student experiments. Other samples were brine shrimp, loblolly pine seeds, bread mold, Spanish moss, popcorn, and magnets.

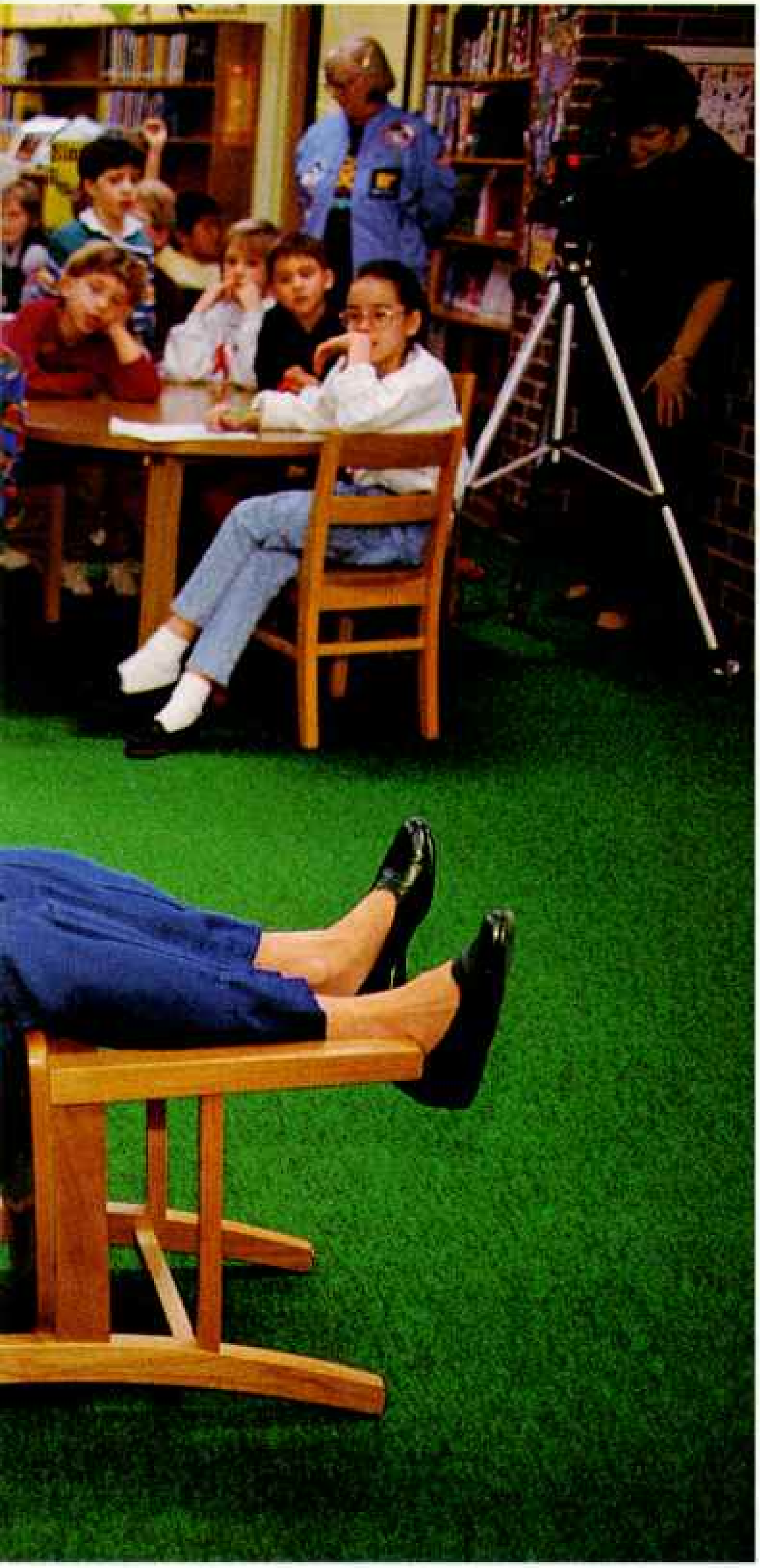
"It wasn't just a stunt. The samples were part of real experiments," says author Nicholson. "Each sample was duplicated in five test tubes. One went into orbit, one was exposed to intense radiation, one was frozen, one was spun in a centrifuge to a G-force simulating gravity on Jupiter, and one was kept as a control."

After *Endeavour*'s return the students evaluated the contents of each vial in a blind study, not knowing which tube had gone into space. So far, the most noticeable mutations have been in the irradiated samples.

With the CAN DO data in hand, the Charleston schools are working on ways to keep the spirit of the project alive. Students shared their research results at a spring symposium; teachers are building geography lessons around the GEOCAM images.

At Mary Ford Elementary School (above), teacher Beth Anthony helps second graders take turns piecing together the GEOCAM Zaire River mosaic.

"The important thing is that the benefits of CAN DO are not limited to any one type of student," says Carol Tempel, who coordinated CAN DO for the district. "Gifted students, average students, special-ed students, students of all backgrounds sent little pieces of their imagination into space."



Flight school

Lying down on the job is a big part of being a shuttle astronaut, as Janice Voss-Ford explains to students at the Orange Grove Elementary School. Asked what it's like to fly aboard the shuttle, Voss-Ford flipped her chair on its back and assumed launch position. February's session with Voss-Ford—one of six crew members during CAN DO's flight—was telecast by closed circuit to the rest of the school.

Such educational efforts by NASA—even after CAN DO's flight was long over—typify the contributions of time and expense from the more than 30 corporations and organizations that made the project possible.

"A NASA engineer estimated that a payload like ours could cost more than a million dollars," says Nicholson. "But thanks to the generosity of everyone involved, this one ended up costing the school district less than $2,000."

For Charleston's students, the investment is paying off in a lifetime supply of self-confidence. One girl explained, "Usually when we're allowed to do something that involves real responsibility, it's like driving the car sitting on Daddy's lap—you have your hands on the wheel, but a grown-up is in the driver's seat. Here with GEOCAM, we really were in control!" □

Pollution in the

LETHAL

LEGACY

By MIKE EDWARDS
ASSISTANT EDITOR

Photographs by GERD LUDWIG

The story on these pages is not a pretty one. It stems from decades of neglect and abuse of a vast and beautiful land—the former Soviet Union. In their ruthless drive to exploit and industrialize their nation, Soviet leaders gave little thought to the health of the people or to the lands that they ruled.

The results are appalling, and a lesson to all. No country, including our own, is free from the scourge of pollution; the Soviet example is simply one of horrifying extremes.

Here photographer Gerd Ludwig's Russian assistant stands on the shore of the Baltic Sea in the Estonian town of Sillamäe. Radioactive waste from a plant that once processed uranium for the Soviet military sends the needle of his Geiger counter soaring.

A bitter dilemma confronts the 15 nations that once formed the Soviet Union: With meager resources and almost no funds, how to restore their lives and lands to a measure of the health they once knew. —THE EDITOR

Former U.S.S.R.

■ Eight children of Moscow, all from two neighborhoods, share the same birth defect. Their common plight was revealed when one of their mothers, Tamara Kapanadze, on her own initiative compiled a map using data drawn from hospital archives and a factory that manufactures artificial limbs for such children. Since 1973, she discovered, at least 90 children have been born in Moscow with terminal-limb

deficiency, most missing the left forearm. More than half the children were from homes clustered in a few widely scattered neighborhoods where the air and soil are heavily contaminated by industrial emissions. Although no certain links can be drawn between these defects and Moscow's bewildering mix of pollutants, the incidence of congenitally deformed children appears to be higher here than in Russia as a whole.

■ "Bouquet of Magnitka," the inhabitants of Magnitogorsk call it, the noxious smoke from their economic life-support system—the world's largest steel mill. The city of 435,000 was born on the Ural River in 1929 with Joseph Stalin's first Five-Year Plan and soon became a showcase for the Soviets' industrial revolution. Today, still using some of its old furnaces, the complex employs 50,000 workers to produce

12 million tons of steel yearly. In contrast, a state-of-the-art mill like the U. S. Steel plant in Gary, Indiana, produces seven million tons with only 7,500 workers. As with all Soviet steelworks, gas and dust filters for the smokestacks here are often missing or inoperative. A third of the city's inhabitants suffer from respiratory ailments, including asthma and chronic bronchitis.

"They used to show us films of the corrupted

IT LOOKS LIKE A YELLOW PLASTIC FOOTBALL. Snap it open and out falls a gas mask.

Rumiya Dzhenbulatova's family has five footballs, one for each person. "When I see Luisa's nose bleeding, I know it's the gas again," said Rumiya, a handsome woman with dark Tatar eyes. She nodded toward her four-year-old. "She's the first to be affected. Then I smell it. It's like bad eggs. We all feel sick; the kids get dizzy."

This happens in the village of Seitovka, 25 miles from Astrakhan in the Volga Delta in southern Russia. From Seitovka it is only a couple of miles across the sere floodplain to the sulfur plant that purveys fear and danger to 3,000 families. Conceived in one of the Soviet Union's bouts of *gigantomaniya*, at full bore it would be the world's largest sulfur works, extracting four million tons a year.

The gases that besiege villagers are sulfur dioxide and hydrogen sulfide. The first probably causes Luisa's nosebleeds; rotten-egg-smelling hydrogen sulfide is a killer.

"This is not a milk plant," director Viktor Shugorev said of the Astrakhan gas complex, as it is known. Indeed. In a single accident four people died from escaping gas.

"Doctors say, 'You have to leave for the sake of your kids,' " Rumiya told me. "Where would we go with three kids? The plant keeps promising to build houses for us somewhere else, but nothing happens."

Apparently, finally, new homes in a distant town will be built this year. In the former Soviet Union this is a rare victory over an industrial juggernaut.

For five months I traveled the low road of the sundered nation, from the fouled shore of the Baltic Sea to the troubled forests of the Khabarovsk region, touching the Sea of Japan (map, pages 80-81).

Determined to transform their peasant society into a mighty empire, the communist bosses hammered and sickled the environment across this 6,000-mile breadth. While professing respect for nature and concern for workers, they killed rivers, even a sea; killed forests and tundra; and killed people.

It began in the late 1920s under the dictator Joseph Stalin, who created in Magnitogorsk, Norilsk, and other cities steel mills and smelters that poisoned the air and rained acid upon the landscape. At that time industries worldwide were careless about the environment. But many Soviet enterprises stayed that way. Others progressed only to the modest U. S. environmental level of the 1960s—at best.

In the 1960s the oil and gas of Siberia were targeted for massive development, and who cared if rivers ran like purple rainbows? Who cared if the Soviet patrimony burned in gas flares so bright that cosmonauts said they rivaled Manhattan's glow?

Even more reckless were the nuclear cowboys, a bureaucracy amok. Incaution was a common denominator of the nuclear arms race, and in that category, at least, the Soviets won. For example, they emptied a small bomb's worth of radioactivity into a river drunk from by unknowing peasants. The same bureaucracy created the reactor that blew up at Chornobyl (see following story).

From talks with health officials, I know that

Photographer GERD LUDWIG teamed with MIKE EDWARDS for a three-part article on the former Soviet Union, "A Broken Empire," in the March 1993 issue. Born near Alsfeld, Germany, Ludwig lives today in Los Angeles.

West with its polluted waters...."

■ Mocking a forgotten holiday, the ghost of Chornobyl blows through Prypyat, a Ukrainian city built for the workers of the ill-fated power complex. On April 26, 1986, as this amusement park was being readied for the annual May Day celebrations, the world's worst nuclear accident contaminated thousands of square miles, forcing more than 150,000 people to abandon their towns and villages.

industrial and auto pollution in sum are of greater danger than radiation. But the atom has a scarier reach; in Russia, Ukraine, and Kazakhstan radiation-damaged genes may threaten thousands yet unborn.

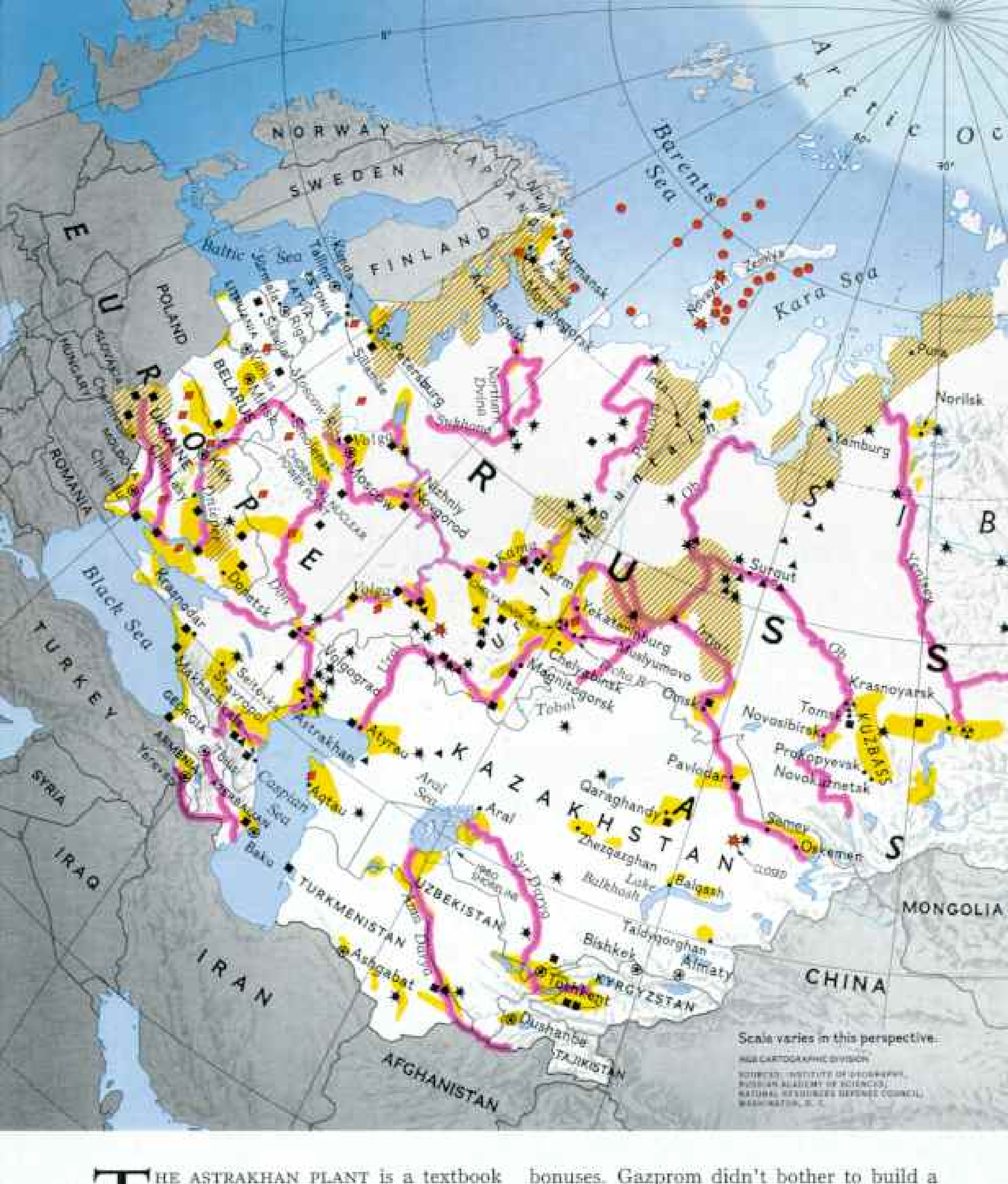
Western Europe, which received fallout from Chornobyl, has urged Russia, Ukraine, and Lithuania to impose stringent safety measures or shut down unsafe reactors.

Scandinavian nations protest smelter exhaust from Russia's Kola Peninsula. Industrial toxics waft across the Arctic to Alaska and Canada, while effluents from Siberian rivers foul Arctic fishing grounds. Even more worrisome to these neighbors, and also to Japan, are revelations of wholesale nuclear dumping at sea.

I found little likelihood that things will improve soon; the economies of Russia and most of the other 14 former Soviet republics are in shambles. "They used to show us films of the corrupted West with its polluted waters, like your Great Lakes," a Siberian environmental worker said. "Now the situation you had in the 1960s is here. But if the chaos continues, we will need two or three times as many years as you needed just to *decide* it's necessary to clean up."

■ With forests of oil rigs in their backyards, the children of suburban Baku in Azerbaijan have learned to enjoy the viscous pools of runoff from the dilapidated and leaky pumps. Adults worry about fire hazards. Once the U.S.S.R.'s major source of oil, Azerbaijan's oil fields fell into decrepitude after the Soviets began exploiting their great Siberian deposits in the 1960s. Like all Soviet successor states, Azerbaijan has

been left holding a bag of environmental horrors. With its economy in ruins after a six-year war with Armenia, it can ill afford to modernize its ailing oil industry. Western companies, eager to tap into the still rich Caspian oil fields, may offer a means. First, however, Azerbaijan must work out an agreement with one or more of its neighbors on construction of a pipeline from the landlocked Caspian to the open seas.



THE ASTRAKHAN PLANT is a textbook case of how not to industrialize. The Soviet Union needed sulfur for industrial processes, and to Gazprom, the state gas monopoly, the ideal source was an oil-and-gas deposit beside the Volga. It was laden with sulfur—principally in the form of hydrogen sulfide.

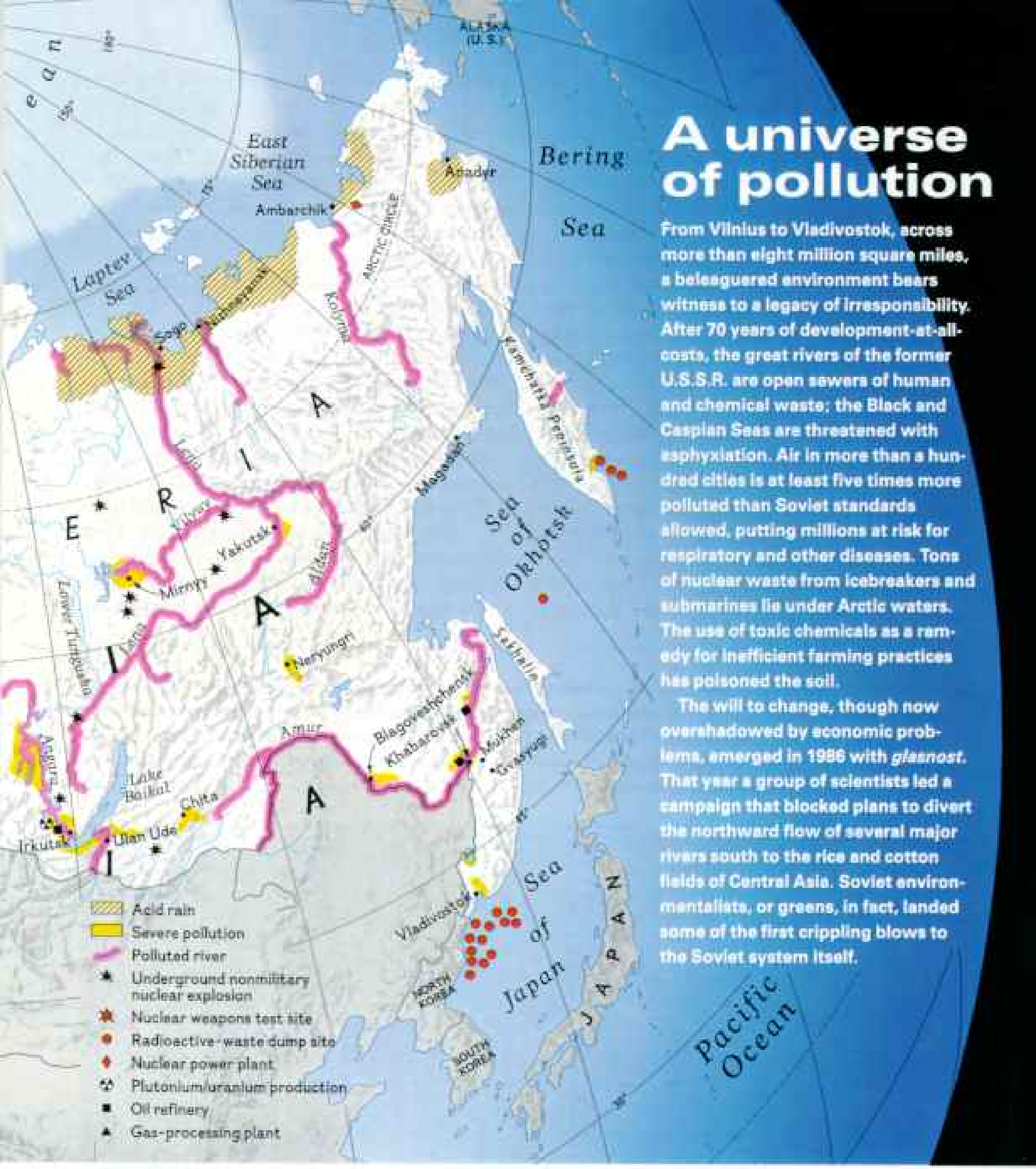
As usual Moscow wanted quick results, and local bosses were eager for recognition, if not bonuses. Gazprom didn't bother to build a generating plant to supply the huge sulfur works with electricity and soon found the regional power grid inadequate. Power failures caused hundreds of shutdowns, compelling workers to vent their deadly feedstock.

Gigantomaniya appeared yet again here, in plans to create underground gas reservoirs. Fifteen atomic devices were detonated—far beneath the surface but only a few miles from

villages. Altogether, the Soviet Union pulled the nuclear trigger 116 times for "peaceful purposes" such as mines and canals, continuing long after the United States abandoned the atom as a risky excavator. All but two of the Astrakhan cavities caved in and thus are useless, save to give work to engineers who will monitor them for 25 years. At least one leaks low-level radiation.

Sometimes after visiting such places my interpreters complained of headaches and sore throats—the complaints of nuclear workers. I never felt affected, even after standing atop a reactor at Smolensk. Reactor crews told me that vodka washes radiation from the system, and so I washed. (I am bound to report, however, that doctors say I was misinformed.)

Pollution came in many guises, not the least of them architectural. The fortress-like Communist Party headquarters and other



buildings executed by Soviet architects stamped an Ozymandian character ("Look on my Works, ye Mighty, and despair!") upon not only Moscow but even minor cities.

Riga, the Latvian capital, survived better than many, salvaging its old quarter, a tight jumble of spires and turrets. Here I met members of the Environment Protection Club. Like many former Soviet "green" organizations it is on hard times, behind on the rent and the phone bill. Members look back nostalgically to 1988, when they mustered 50,000 citizens to demand sanctity for the old city, endangered by a planned subway. Tunneling, they feared, would shake the buildings apart.

In the 1980s Moscow allowed environmentalism under Mikhail Gorbachev's openness policy, *glasnost*. Suddenly the green movement burgeoned everywhere, a vehicle for venting anger against Soviet power.

In the Baltic States, greens were in the vanguard of the freedom drive. But after independence in 1991, and facing the hard task of nation building, Latvians lost interest in saving churches. They no longer needed to shout "Down with communism!" Raitis Bukoviskis, a young activist, told me: "Today people say to us, 'You can shout—what else can you do?' " That's the question dedicated greens all over the former U.S.S.R. must try to answer if they are to enjoy credibility again.

After a half-hour drive from Riga I was in a venerable Baltic spa, Jūrmala. The beach was an arc of powder, the Gulf of Riga a disk of shiny obsidian. But Jūrmala's old ambience—gingerbread buildings clasped by pine—had not escaped as Riga's had. Near me an arrangement of concrete boxes cascaded toward the water; it had been a KGB resort.

"We had to do a lot of things that had never been allowed," environmentalist Ieva Shprunka said. Jūrmala had never had buildings on the beach—much less concrete boxes. No structure rose higher than the local pines;

■ **Exhausted after a day's exposure to dust, masked workers breathe deeply while leaving the giant cement plant at Kunda. Though one of Estonia's most polluted towns, Kunda is a safe haven compared with Chelyabinsk, a Russian city where area residents are undergoing lung and other diagnostic tests (right). Unknown to them, a nearby lake and river were used for years as dumps by a weapons plutonium plant. The lake shrank in a 1967 drought, and thousands of people were exposed to wind-borne radioactive dust.**

Pravda built a high-rise for its senior editors. The party Central Committee, the Writers Union . . . on and on rose the affronts.

How much better it would have been if some of the funds lavished on the comfort of big shots had been spent on Riga's sewage plant. For years untreated sewage has poured into the Gulf of Riga; warnings are posted that to bathe at Jūrmala is to bathe in someone else's bacteria. The Soviet disdain for sewage treatment, as I discovered, stretches from the Baltic to the Sea of Japan, as if Moscow truly believed that the "new Soviet man" it was inventing was immune to coliform.

IN MID-MAY, when I flew to Murmansk, 875 miles north of Riga and nearly 200 miles above the Arctic Circle, spring was still winter but twilight came at midnight. In a month the sun would coax the birches into leaf and brighten night to white. Now the sky spit snow.

Murmansk was leveled by the Germans in World War II while receiving war goods convoyed at fearful cost through waters infested with U-boats. My drab hotel overlooked a boxy city rebuilt beside the inky Kola Bay.

The Kola Peninsula, isolated realm of rock and reindeer, is ironically earth's most nuclear region. Among the vessels within my gaze were five big nuclear icebreakers, a nuclear cargo ship, and two of the hundred or so nuclear submarines based in nearby ports. Oh yes: There's a nuclear power plant.

At a dock rode *Lepse*. An icebreaker tender, her main job had been nuclear waste disposal. In Arctic waters she used to hoist a flag signaling engine trouble, in case she was being observed by the craft of some other nation, such as Norway's fishing fleet. Then, circling as if disabled, *Lepse* spewed thousands of gallons of icebreaker waste. *Lepse* had "engine trouble" two or three times a year.

The arithmetic of Arctic abuse staggers: 14 reactors dumped (four with fuel); one disabled sub sunk, with fueled reactors; 17 other contaminated vessels sunk; and thousands of barrels of solid waste tossed over. Norwegian scientists fear that in places the Arctic food chain—plankton to fish to mammals—is radiation tainted. Two more reactors as well as waste were dumped in Far Eastern waters.

This, one of the dirtiest Soviet secrets, unraveled in 1991, thanks in part to Andrei Zolotkov, an engineer for Atomflot, the icebreaker fleet. No flaming environmentalist, he nevertheless was intrigued when a Greenpeace boat put in to Murmansk in 1990. He joined its antinuclear crew on a voyage to protest at Novaya Zemlya, the Soviet nuclear test islands, a brash mission that attracted an armed boarding party.

"But before that, on the boat, we talked a lot," Andrei told me. He was shocked to learn that the Soviet Union had signed an international antidumping agreement in 1976. "I had never known about it. How could it be that we'd been living this lie for years?"

The following year, he stood at a Greenpeace press conference in Moscow, a whistleblower pointing to dump sites on a map.

"You'll get what you deserve," angry officials threatened. Instead, Atomflot got a new boss willing to acknowledge the truth. Andrei still has his job.

I boarded *Imandra*, a ship that never goes to sea. She just chugs a mile or so in Murmansk harbor to load fresh fuel, in ten-foot-long metal rods, into the icebreakers. The risky work takes place almost under the eaves of apartment buildings. Below *Imandra's* decks my radiation meter went crazy. Some of the 1,200 spent rods stowed there had been aboard for four years; the reprocessing plant at Chelyabinsk-65 was behind in its work.

Lepse, moored nearby, today carries a worse cargo: More than half the 650 rods in her hold are cracked and leaking. "They'll have to bury her," Andrei said. "Dig a canal, push her in, and cover her"—after filling her with concrete.

THE NARROW HIGHWAY south from Murmansk threaded piney woods that looked almost luxurious, given the harsh Arctic climate.

But after two hours I was among snags: trees bleached or blackened by fire. A few jaundiced saplings are the sole survivors of a forest devastated by acid rain.

Close by, in the city of Monchegorsk, sprawls the Severonikel *kombinat*, a huge nickel producer, yielding also copper and cobalt. Its stacks pour sulfur dioxide as well as toxic metals upon the arboreal graveyard.

Miners worked nearby ores in the 1930s. Pollution wasn't bad then; the smelter was small, the ores low-sulfur. But by the late '70s the mines were depleted. To keep the smelter going—and to expand it—ores measuring 30

■ Blighting the lush forests of Russian Lapland, broad belts of pine and birch succumbed to acid rain, then to wildfires. Some of the survivors bear foresters' identifying markers. Among the polluters: a nickel smelter in nearby Monchegorsk. In the great forests of the Far East, where decades of clear-cutting have already left scars, foreign timber companies are moving in—a cause for concern to environmentalists.

percent sulfur were shipped here from Norilsk in Siberia, where smelters already had blitzed a great swath of tundra.

Today high-sulfur ore goes to both Monchegorsk and another Kola smelter at Nikel, from where sulfur dioxide plus moisture—acid rain—patters down on Norway and Finland.

Monchegorsk poisons fall heavily on the Laplandskiy Zapovednik, or nature preserve, created to protect reindeer. A quarter of the thousand-square-mile preserve is damaged; some areas are dead. Heavy metals are widespread. "The soil will need 400 years to cleanse itself" is the gloomy estimate of naturalist Igor Paraketsov.

I sojourned at Igor's camp, gazing across a lake half sheathed in ice to matted conifers. Few Russians know such solitude in a lifetime. But even here, 20 miles from the smelter, acid rain is balding the pines.

Nature study as practiced from the camp requires a keen eye. Year after year Igor plodded the same paths, jotting down evidence of mice or bears and counting bird nests and mushrooms. "In some places the mice are gone," he said. "The metals affect them. They become weaker and just disappear. Birds, fish, everything is affected."

In Monchegorsk, a gloomy city emblazoned with old shibboleths ("Glory to the Soviet People!"), I asked in vain for figures on cancer and respiratory problems, the expected consequences of living by a dirty smelter. Doctors admitted that rates are higher than elsewhere, but they appended: We don't find a clear link between smelter and health. Translation: We don't dare offend the kombinat.

They would have been surprised to hear kombinat director Vasily Khudyakov meet reality head-on. "We destroy nature; we destroy

■ Baffling cases of baldness among children in Ukraine are raising alarms among doctors like these in Kiev examining young Sasha Perepelitsa of the Cherkasy region. A sudden outbreak of the condition, known medically as alopecia, occurred in 1988 in the city of Chernivtsi, where more than a hundred children lost their hair while suffering from a host of more serious health problems. Such medical mysteries are

cause for anxiety in Ukraine, where a dramatic increase in thyroid cancer among children has been attributed to the Chornobyl accident. Throughout the former U.S.S.R., deteriorating medical services compound the health crisis. About 40 percent of hospitals lack hot water, hypodermic needles are routinely reused, and a shortage of vaccines has led to outbreaks of diphtheria.

■ From their skin to their genes, children of the old empire pay for their elders' follies. In Kiev a girl's dermatitis is but one example of the increase in allergic diseases. At Magnitogorsk — where birth defects are reported to have doubled since 1980 — space in the homes for mentally retarded youngsters is at a premium. Fifteen-year-old Dima, front right, declares: "I love America; I will go there and become president."

the health of our people," he acknowledged. It was 6 p.m. when I entered the office of this bluff man with loosened tie. He had been at work since 8 a.m.; privatization means long hours as well as opportunity.

"We had to do as Moscow dictated," he said of the past. "The task here was to produce metal. The government never would finance ecological measures."

No doubt obdurate Moscow bureaucrats were ultimately responsible for the absence of cleanup facilities in Soviet enterprises. But the record also shows that when local bosses were confronted by greens in the 1980s, many furiously resented their "meddling." Some still consider activism an evil consequence of the new "democracy."

Vasily Khudyakov spoke like a capitalist. "Putting out all that sulfur, we were throwing our money to the winds," he said. The kombinat now converts some of the sulfur to sulfuric acid — a salable product — and it is buying equipment from an American company that will allow it to convert more.

The kombinat is also building a new hospital for Monchegorsk and even plans a church — penance for years of sin, surely.

IN MY MOSCOW APARTMENT the tap water had an aroma stranger than usual. I learned why from TV. "I am very sorry, dear Muscovites," a waterworks official began. He explained that because farmers near the reservoirs were depositing manure on their fields, the capital's water — running off those fields — required treatment with powerful chemicals. It often happens in spring.

In another apartment this scene happens sometimes: Zhenya, who is six, asks, "Mom, when will my left hand grow?" and his mother turns away crying.

"I can't answer him yet," Marina Zibrova told me.

Was it some chemical — in the air, in water, in food — that caused Zhenya's arm to stop developing below the elbow when he was still in

"We had to do as Moscow dictated.... The govern

the womb? There is no clear evidence. One circumstance, however, prompts some doctors to suspect pollution. In Zhenya's neighborhood of high-rises and factories in northern Moscow, four children with shortened left arms were born in just over nine months, between September 19, 1987, and July 1, 1988. Two of the families lived in adjacent buildings.

It was Tamara Kapanadze who discovered that other babies like her daughter, Sonya, were in the neighborhood.

Sonya, a blond sprite, pasted paper as Tamara talked in their tiny apartment. Attached to Sonya's left arm was a prosthetic device with a small plastic hand. "This child has become so dear," Tamara said. "I take what happened as a gift from fate."

But why, why? Tamara galvanized other mothers. They wrote to health agencies. Eighteen letters elicited only four replies. Eventually, however, geneticists investigated. This led to the discovery of a second cluster of four children with shortened left arms in a neighborhood less than three miles from Tamara's. They were born at about the same time. The geneticists concluded that the clusters were coincidence.

Terminal-limb deficiency, as this birth defect is called, occurs worldwide at a rate of once in 4,000 births. Clustering is not unknown. But some scientists believe the Moscow clusters are more than coincidence.

The Moscow sanitation office (a health agency, not a garbage collector) has tentatively blamed the industrial chemical dioxin. American experts question that finding; dioxin has not been tied specifically to terminal-limb deficiency.

We may never know the cause, although geneticists at the U. S. Centers for Disease Control have expressed interest in working in an investigation. What we do know: Birth defects in Moscow are alarmingly high. And the infant death rate stands at 15 per 1,000 live births, nearly twice the U. S. rate.

The capital's hazards shame the young biochemist who heads Moskomprirodа, the city environment agency. "It may become so dangerous to breathe in Moscow that we will be wearing masks," Alexander Ishkov said. "Cancer-causing pollutants exceed acceptable norms many times over in some neighborhoods." Much of the toxic load is exhaled by Moscow's 1.3 million motor vehicles; virtually none have exhaust-cleaning devices.

Environmental agencies can fine polluters, but real clout is missing; Moskomprirodа received no funding for four months last year while national and city officials argued over who had to ante up. Still, I am told, no longer can a big boss phone the environment office and command it to withdraw objections to some new enterprise. That's progress.

The Kuryanov sewage-treatment plant, one of four catering to Moscow's needs, has an intimate Kremlin connection—it receives the omniscient flush.

In a field nearby I sniffed ten million tons of sewage residue, biologically treated but still fragrant. In other countries this sludge might become fertilizer. But Moscow's is laced with cadmium and other possible carcinogens; few of the city's 2,800 factories have equipment to remove metals, dioxin, or PCBs. Waste piped to Kuryanov and other treatment plants brings 15 tons of metals daily; three tons pass into the Moscow River and on to the Volga.

In a small office crowded with computers, biologist Sviatoslav Zabelin said, "Industry's attitude toward the environment hasn't changed." The fines imposed for dumping are in his opinion merely symbolic—for many malefactors, just a business expense.

"Svet," who once studied the antennae communication of ants, leads the Socio-Ecological Union. Thanks to U. S. support, some of its 200 member groups share environmental news via computer modems. "Without this it would be hard to fight," Svet said, "because the mails are so unreliable now."

Svet campaigns to change the gigantomaniya way of thinking. He notes despairingly that the Ministry of Atomic Energy—the unregenerate bureaucracy that contaminated vast areas and built Chornobyl—now proposes to build 30 more reactors. "We should create efficient industries instead," Svet said. "Our factories use three to five times more energy than in the West to make the same goods."

Selling efficiency may be hard. People

ment never would finance ecological measures."

worried about whether they will have jobs tomorrow may conclude that any construction program is fine. As another environmentalist said, "When people became involved with their stomachs, they forgot about ecology."

I WENT SOUTH to Kazakhstan and at 4:45 a.m. stumbled off a train in Aral. This city sent fish to Russia and loaded machinery on steamers destined for ports on the Amu Darya in Uzbekistan or Turkmenistan—before the Aral Sea, once larger than West Virginia, was destroyed by irrigation schemes.*

Sunup revealed the city as low and gritty. Where Aral waters once lapped, naked seabed gleamed with salts.

The sea is so far away now that to view its remains I needed an aircraft. The civil airport had planes but no gas. I tried the small military station. Like many things after the Soviet collapse, it just collapsed too; barracks stood looted of doors and windows. But one helicopter could fly, and there was fuel. After a donation to my pilot's welfare (business is business) I was aloft over what had been a rich oasis.

Beneath me was only salt pan. Finally we reached water, but not a sea. Shrunken to half its former size, the Aral has divided into two shallow bodies—briny lakes in a platter of caustic marzipan.

Citizens went along docilely with Moscow's decision to irrigate huge cotton and rice crops from the Amu Darya and Syr Darya, the only rivers feeding the Aral. "The Syr was such a great river, we never thought it would go dry," an old fisherman told me. But by 1975 both were trickling cesspools. And while evaporation shrank the sea, over-irrigation encrusted the land with chlorides and other harmful compounds.

In Aral city I went to the hospital. It stands upon seabed, as if to confirm that the sea won't return. Through the corridors floated the wails of children. An old woman hobbled past, doubled upon her cane.

After an afternoon there, I knew that the Aral ecosystem is not the only disaster. Two million area residents have gone to health hell.

Beginning in the 1970s the people were scourged by epidemics: hepatitis, typhus, and other diseases. They drank from the rivers, as always, but now the shrunken rivers ran gravid with sewage, industrial metals, and poisons such as DDT. "It wasn't possible to mix infant formula with that water," said Dr. Ulsada Yesinzholova, the chief pediatrician. "It made goo, like soft cheese."

Dust storms often blow for days, sweeping up tons of salts, pesticides, and fertilizers. Doctors brace then to receive children with respiratory problems.

These, plus dysentery and diarrhea, figure in the high infant death rate. Another factor: the poor health of mothers. "Eighty percent of the mothers are anemic, so many of these kids are unhealthy from the first day," Dr. Yesinzholova said. Dust makes people susceptible to one more rampant affliction: tuberculosis.

"Every patient," another doctor said, "is a bouquet of illnesses."

In the grim litany repose questions never researched. Does the lopsided Kazakh diet—meat and (formerly) fish, with few vegetables—cause the widespread anemia? What role do toxics play? The only good news is that people are starting to get cleaner water, from wells. The rivers trickle as meagerly as ever.

KAZAKHSTAN, declared a Kazakh writer, was Moscow's "junk heap," the locale of its dirtiest endeavors.

Atop his list, surely, was the eastern city today called Oskemen (known by a Russianized name, Ust Kamenogorsk, before the Soviet breakup). It guarded Russian trade routes to China under Peter the Great. The Soviets made it a smokestack citadel.

Virtually at midtown sprawls an aged lead-and-zinc smelter equipped in part with machinery borne from Germany as reparations after World War II. Expanding, it produced nearly half the U.S.S.R.'s zinc and lead. Also here: a smelter of titanium and magnesium and a plant turning uranium into reactor fuel rods (some destined for Murmansk). The fuel plant's tailings pile set my radiation meter buzzing as I stood 300 yards away.

Doctors long knew that serious problems

*See "The Aral: A Soviet Sea Lies Dying," by William S. Ellis, in the February 1990 GEOGRAPHIC.

afflicted the 300,000 residents. Infant mortality was higher than the Soviet average; 40 percent of the surviving children were chronically ill. The average age at death for men was 55—10 years younger than elsewhere in the nation.

From time to time clinics would suddenly fill with people, especially children, suffering from nosebleeds. No one knew why.

When it happened again in April 1990, the doctors heard that an accident had occurred at the lead-zinc smelter. Some toxic evidently had escaped. The deputy health director, Dr. Kaydyrbek Andagulov, ordered the bleeders tested for lead. The results staggered: 34 blood samples analyzed, 34 high in lead content.

The KGB soon knew; its informers were ubiquitous. "They called me in," said Dr. Andagulov, a slight, intense man, "and forbade me to make a diagnosis of lead poisoning." Such was the way polluters were shielded from public outcry.

Dr. Andagulov didn't retreat. Secretly he and colleagues analyzed tissue and bone from corpses. Conclusion: The whole population was laced with lead.

In fact, lead almost certainly did not cause the nosebleeds. It dulls children's IQs and in heavy doses may cause seizures. But nasal irritation is not a known effect. The people had breathed some other toxic as well.

As the Soviet Union veered toward collapse, the KGB lost its grip on industrial secrets. Kazakhstan's government ordered a major health study. To Oskemen came Moscow experts who sampled everything from soil to urine. Among the findings:

- Lead and zinc are in the soil, in the cucumbers of home gardens, in water, in air, in mother's milk. Other poisons are also present from smelted ores: arsenic, mercury, cadmium.
- Immune-system abnormalities afflict 58 percent of the children, predisposing them to viral infections and other diseases.
- Chromosome damage is widespread. Aberrations were discovered in 60 of 103 young people tested. Possible consequences: cancer and birth defects.

Mercury and cadmium have been linked to chromosome damage in studies elsewhere. But the broken and contorted chromosomes that appeared under researchers' microscopes may have been caused by radiation, doctors say. Radiation may also have contributed to the high rate of immune system abnormalities. The doctors suspect that the fuel-rod plant is a source and also wonder how much fallout rained on Oskemen from the nuclear weapons test field at Semipalatinsk (today Semey), only a hundred miles west. Testing ceased in 1989 after 470 blasts, 116 in the air.

Oskemen may be the most hazardous city in the former Soviet Union. The cancer rate—288 cases per 100,000 people—is higher even than the rate near the test field. Perhaps it is a consequence of double jeopardy: radiation and metal poisoning.

IN MUSLYUMOVO, a village of 2,500 Tatars and Bashkirs near the Ural Mountains in Russia, a man in his 40s—I'll call him Yusef—told me in a quiet voice: "I am infertile."

"There are many here with the same condition," he added. "It's disappointing not to have a son. But at least, whatever is wrong with me will end with me."

■ Black is the driven snow of Prokopyevsk, one of several cities in the mineral-rich industrial hinterland of Siberia known as the Kuzbass. More than snow is tainted by the sooty emissions from dozens of chemical, mining, and metallurgical enterprises in the region—respiratory and other diseases are on the increase. Children, with their smaller lungs and more rapid respiration, are most vulnerable.

I had flown northwest to Chelyabinsk, a city of ponderous Stalinesque architecture. Then it was an hour's drive to Muslyumovo and its muddy streets. Sprouting wheat cast emerald gauze over soil black as midnight, a scene of promise—only adding to the poignancy here.

The gentle Techa River was Yusef's boyhood swimming hole, as it was for Rafkat Gilyazov, a rickety string bean, aged just 55. Rafkat remembered that in the 1950s "there were two militiamen who tried to keep us out of the river, so we just went a little farther away. The Techa was our drinking water. Our cows went there, our geese, our sheep."

Youngsters and animals alike bore radionuclides home. Fifty miles upstream stood the secret complex named Chelyabinsk-65, producer of weapons plutonium. Between 1948 and 1951 it poured into the Techa wastes containing two million curies of radioactivity—about half the amount released by the Hiroshima bomb. River banks and sediment still tingle with long-lived cesium and strontium.

Thus Muslyumovo is akin in tragedy to radiation-tainted Oskemen, but with this difference: For decades scientists studied the Techa villagers like guinea pigs—but told them nothing.

■ Old before their time, workers take tea and warm themselves between firings of open-hearth furnaces at the Novokuznetsk metallurgical plant, one of the oldest steelworks in Siberia. Victim of a tragic broken promise, the so-called new Soviet man has already ceased to exist politically: now his physical existence is threatened as well. In 1965 life expectancy for men in the U.S.S.R. was 66—roughly on a par

with their U. S. counterparts. Today life expectancies are falling throughout the former Soviet Union; for Russian males it is 61 — lower even than that of many developing nations. Birthrates are also dropping precipitously, and deaths now exceed births in Russia by some 700,000 a year. Only the repatriation of Russians from other former Soviet republics is preventing Russia's population of 148 million from falling sharply.

I met Rafkat in the little cold-water clinic, where 20 people awaited the doctor. In 1955, when he was 16, he was among a group of villagers taken to Moscow for medical tests, he told me. Periodically he was reexamined. "I would ask, 'What happened to us?' and they would say, 'This is none of your business.' "

His weight fluctuated. "My joints ached almost permanently." He had to give up his job as a tractor driver—"With all the levers and the wheel, you need strength."

The doctors' secret diagnosis was chronic radiation sickness from prolonged exposure. Weight loss, aches, and weakness are symptoms. Soviet doctors say the disease may include immune- and nervous-system disorders, with a higher than average cancer risk. U. S. specialists hardly know this diagnosis; our weapons plants polluted but (so far as is known) never spawned a Techa.

Rafkat learned of his diagnosis only last year, after the local doctor, Gulfarida Galimova, pried a list of names out of the scientists who conducted the clandestine study. Many of the 300 Muslyumovo subjects were dead, some of cancer. One by one she called in the living to tell them.

While I was in the clinic, Dr. Nina Soloviova, a geneticist, finished examining 12-year-old Ilshat Nuriev. She playfully pinched his belly, then turned to Ilshat's mother and said sternly: "This boy must be moved. If he stays here and receives more radiation, he will be seriously sick." Ilshat's mother, Faniya, nodded. Her lips were thin and tight. Where might the family go? She had no idea.

Dr. Soloviova had done DNA tests. "The frequency of mutation is usually one in 20 or 25 people," she said. "In children here it is one in six or seven. This is a terrible crime."

The Chelyabinsk-65 record is gruesome. A 1957 explosion contaminated a 185-mile tongue of farmland. A horrific 120 million curies was drained into a nearby lake. When the lake shrank from drought, winds swept dust from its bed. The Techa dumping was the worst; officially, 940 villagers got radiation sickness. The true figure may be several thousand.

The total radioactivity that spread from Chelyabinsk-65 or accumulated in the waste lake is about 40 percent more than the 100 million curies expelled at Chornobyl. Chelyabinsk, however, exposed a *mere* 440,000 people, while Chornobyl's farther spreading nuclides fell at least in small quantities upon 4.9 million Soviet citizens.

I WENT NORTHEAST from Chelyabinsk to Surgut, where Russia is a wastrel.

On a June evening in Surgut men stand on the balconies of their peeling apartment buildings and gaze across an ineffable flatness of pine, marsh, and silvered lakes. A breadboard landscape can be arresting like a mountain range or boring, depending on your viewpoint. Either way, Siberia's immensity is compelling. And the riches! Thirty percent of the world's natural gas and 5 percent of the oil, plus timber, coal, diamonds, gold, and many other treasures.

Surgut exploded in the oil-development campaign of the 1970s. Today grown to 300,000, it wears rawness like a badge. Copper engine gaskets surmount the rooftops—your rough-and-ready TV antennas.

Pay envelopes are fat by Russian standards; workers earn $350 a month. "Which we spend as fast as we can," said Viktor, an engineer. "No use saving—with inflation your money will buy less tomorrow. New furniture, new clothes: Out goes the old, in comes the new."

Dollar fever runs full throttle; even an environmentalist, so-called, asked me to pay a driller's monthly wage, and more, for a few hours of his time. Real environmentalists are a rarity in the oil-and-gas towns. "It's a tradition here not to obey any laws," a worker said.

I chartered a chopper (no fuel shortage in Surgut) and flew over two oil fields in swampy flatwoods northeast of where the great Ob River wheels and aims for Arctic seas. Duckbill pumps pecked away. In 1992 Surgut yielded 265 million barrels of oil, more than enough to supply a country the size of Australia.

It wasn't hard to spot the spills: black splotches alongside drilling gear or the pipeline spaghetti. Pipes supposedly good for 25 years often rust out in two.

Much oil gets into lakes and streams, with consequences for Siberia's bird populations—geese, cranes, curlews, and many others. Oil renders their feathers useless against cold and destroys the insects they depend on for food.

We clattered toward tall stacks. Orange fireballs roared up as if to consume the helicopter like a flame-lured moth. The wholesale burning of "associated gas"—natural gas that rises with extracted petroleum—has long been one of the sorry aspects of Siberian energy

■ Where fish swam, camels now tread over the floor of the Aral Sea. Once a striking body of blue on the world globe, the bountiful lake has shrunk to half its former size and is now two shallow lakes far from the old shores. Diverting vast amounts of water from the lake's two feeder rivers for the irrigation of cotton and rice, Soviet planners ignored the predictable consequences to achieve short-term production goals.

development. Though more gas is utilized today, the incinerated amount remains enormous; according to one Western expert, Siberian fields still flare 500 billion cubic feet of gas a year. Mainland China doesn't consume that much.

Far above the Arctic Circle, Gazprom, the gas monopoly, is moving tractors across tundra to new deposits—while gas burns in established fields. Nothing checks the waste and environmental destruction. At least in Soviet times these were subject to the *plan*.

"THE PLAN, THE PLAN!" Valentina Selina exclaimed, waving her arms helplessly. "That's all that mattered."

Four time zones to the east of Surgut, in the village of Mukhen in the coastal province of Khabarovsk, Valentina, who is retired, still turns choleric as she recalls the pressure on her logging collective to fulfill its quota.

Many women once worked in the woods. Valentina was a sawyer at 15—one tiny cog in the plan. The five-year plans adopted in Moscow were a great gathering of quotas for every worker brigade, every farm and factory.

"But after we got the logs out of the forest, the bosses didn't care any longer," said her husband, Ivan.

"Sometimes they just dug a trench and buried them," Valentina added.

The roads around Mukhen transit emptiness—cutover areas that weren't replanted or long stretches where fire left only snags. Reforestation? Fire protection? Not in the plan.

"For such a long time we had the idea that the forest is eternal—not to worry," said Viktor Skachkov, vice chairman of the regional environment committee. We talked in Khabarovsk, a new-minted capitalist enclave full of

■ "Energy to burn" might have made a Soviet motto. Near the Šiauliai airfield in Lithuania, some residents heat their homes with kerosene skimmed from springwater; it accumulated underground from leaky storage tanks. In the oil fields of Baku, Azerbaijan, explosions and fires are so routine that observers simply shake their heads and go about their business.

imported cars. It stands beside the Amur River, greatest stream of Russia's Far East, draining a stretch of China as well. A badly polluted stream, of course, receiving yet another slug of raw sewage as it passes Khabarovsk.

It's not too late to begin conservation, Viktor argues, even to set aside preserves for protecting wildlife, such as the vanishing Siberian tiger. Indeed, I saw great forests still intact in the coastal region, and I recognized there larch, spruce, and birch. Towering over all was the "Korean cedar," really a pine, sometimes five feet across the trunk.

But by some apocalyptic forecasts the forests could be devastated in 40 years. A recent arrival was the South Korean conglomerate Hyundai, cutting vast tracts. Japanese companies have long logged here; U. S. and Norwegian companies are waiting in the wings. Western environmentalists warn that foreigners will bring to the Far East a forest-consuming efficiency such as Ivan and Valentina's collective never achieved. Or, perhaps, responsible companies will bring an ethic never ordained in the almighty plan. For now, anarchy reigns.

IN THE CLAPBOARDED VILLAGE of Gvasyugi, south of Mukhen, priorities on a different scale consume the Udegei, one of Russia's tiniest minorities. Can they save a few hundred square miles of virgin forest? And when will there be electricity again?

The 1,700 Udegei have kept to old ways, hunting and fishing. Valentina Kyalunzuga, a tiny dynamo who heads the village council, fairly burns as she speaks of loggers. "They cut trees on the banks of the small streams. They dumped oil in those streams and took gravel for roads. You understand, in those streams small fish grew."

The Udegei hope to preserve a wildlife domain where they can hunt, trap, and fish. Timber collectives lust for its trees.

"If the people lose their forest, they won't have anything," village administrator Valery Derbentsev said. The loggers are pressing. Gvasyugi's electricity was supplied by a nearby collective that has turned off the lights. If allowed to cut, it has promised to switch the power on again.

"Do you still have problems with your Indians?" Valery asked me, while describing the Udegei as easily misled, too willing to trade sable pelts for vodka. Alcoholism is just one more Udegei problem.

Inside Gvasyugi's school a Udegei sign greeted me: "*Bagdevits*—Wishing you life." It is a wish we might make to all the former Soviet peoples. They have carried a heavy burden.

Sometimes in my travels across the former U.S.S.R., people said to me: You, the West, are the victors in the Cold War and we are the vanquished. Not so. All of us are vanquished, victims of the ravaging of a great swath of earth. Soviet peoples just happen to live closer to the tragedy. □

Living With the CHORNOBYL

Monster

Eight years after the worst nuclear accident of all time rocked their world, Ukrainians are still haunted by the specter of early death and disability, even for those who were still in their mothers' wombs at the time of the catastrophe. In Kiev youngsters are examined for cesium 137, a long-lived (and carcinogenic) radioisotope contaminating the soil and food chain.

■ Key players in a high-stakes gamble by energy-starved Ukraine, engineers in the control room of Chornobyl reactor No. 3 are careful to maintain power at prescribed levels at all times. In the early hours of April 26, 1986, while conducting a test of their emergency systems, engineers in ill-fated unit No. 4 reduced power to below 25 percent, triggering an explosion and meltdown of the reactor core. Two operators died.

Five survivors were jailed but were later released, since they had not been warned that Chornobyl-style, graphite-core reactors become dangerously unstable at low power. Though universally condemned as unsafe, 15 such reactors still operate in Ukraine, Russia, and Lithuania. With their economies in chaos, all three nations continue to exploit them for electricity.

"Years have passed, and we're just starting to

By MIKE EDWARDS
ASSISTANT EDITOR

Photographs by GERD LUDWIG

NEAR THE END of a half-mile-long hallway connecting the four reactors of the Chornobyl Nuclear Power Plant, graph bars and squiggles flash on a monitor.

Only a few yards away rises the concrete-and-steel sarcophagus sheathing the remains of reactor No. 4, which blew up on April 26, 1986. An estimated 180 tons of uranium fuel remains in the rubble, scattered or fused with melted concrete and steel. Ten tons of radioactive dust coats everything.

Sensors relay information from the debris: neutron activity, radiation, temperature. In the monitoring room the situation report appears on the screen in traffic-signal colors. As I watched, the display was green. If the debris warms up, the monitor shows orange. "If all the indicators turn red, it's dangerous," shift chief Anatoly Tasenko said. "It happens sometimes." He added this nonchalantly, wanting me to know he's a pro.

At condition red, engineers turn on sprinklers, spraying a boron solution that reduces neutron activity and thus the release of radiation. So far, it works.

In fact, Western as well as Ukrainian scientists believe the rubble probably can't reach a critical state—can't explode. But no one knows for sure what's going on within the ruins of the worst nuclear accident in history.

A new study suggests that the explosion threw out 100 million curies of dangerous radionuclides, such as cesium 137—twice as much as previous estimates. The World Health Organization reckons that 4.9 million people in Ukraine, Belarus, and Russia were affected. But the consequences, though obviously tragic in some aspects, remain unclear.

What is clear at Chornobyl, monitor Tasenko's nonchalance notwithstanding, is that the monster is far from tamed.

One major concern of the engineers and physicists watching No. 4 is the sarcophagus itself. Hastily erected after the accident, the 24-story-high shell is leaky and structurally unsound; conceivably it could topple in an earthquake or extreme winds. The reactor building walls, explosion damaged, are unstable too. And the 2,000-ton reactor lid leans on rubble. "If it fell, it could shake everything loose," said physicist Vadim Hrischenko.

In particular, it would shake loose the radioactive dust, which is increasing as the rubble breaks down. A violent upheaval would spread the dust over the countryside—though not so widely as the initial accident, which also contaminated parts of Western Europe.

Finally, experts know that still-working reactors Nos. 1 and 3 are unsafe. No. 2 was shut down after a fire in 1991; its companions continue to run because Ukraine's energy shortage is so dire.

The Chornobyl (in Russian, Chernobyl) power complex, 65 miles northwest of Kiev, the Ukrainian capital, is ground zero in a fenced 40-mile-wide circle. Cleared of its 116,000 residents, it is called the Zone of Estrangement.

My first look inside the zone was upon a landscape that fit the dolorous name. Barn doors hung open and rampant birches grew in flower beds once splashed with hollyhocks. But a few miles farther inside, the zone seemed not so estranged. Despite low-level radiation the 800-year-old city of Chornobyl lives. Its 50,000 inhabitants were evacuated, but in their place have arrived about 6,000 people—guards, drivers, safety technicians, and enough miscellaneous bureaucrats to administer a city of Chornobyl's original size.

Featherbedding, a familiar Soviet labor practice, also prevails at the power station, where engineers admit that the workforce—5,600—is twice as large as needed.

Some workers relish zone jobs because the tasks are challenging, and some, surely, for the

talk about what needs to be done."

■ Nuclear dragon tamers, technicians inspect fuel channels above the core of Chornobyl No. 3, which is separated from the radioactive wreckage of its twin by 200 feet and a concrete wall. Seconds before the 1986 explosion an engineer noticed the lids of No. 4's fuel channels dancing up and down. Six or seven tons of the reactor's fuel load was spewed into the atmosphere during the accident.

recklessness of it all. I put my driver, Sasha, in the latter category when he told me, "I've got boar steaks in my refrigerator." To dine on Chornobyl pig is to dine on cesium and other radionuclides that concentrate at the top of the food chain. But most people work here because, as one woman said, "We've got to work somewhere." In economically crippled Ukraine the choices are few.

The bloated payrolls are one more burden for the Ukrainian government, already pressed by Chornobyl-related expenses such as health care for victims and early retirement pensions for the "liquidators," the hundreds of thousands who cleaned up and raised No. 4's shelter. In all, Chornobyl's aftermath consumes 15 percent of Ukraine's budget.

Beyond Chornobyl city, which is nine miles from ground zero, I passed through a checkpoint with changing rooms. Workers issued me a gauze mask that would filter radioactive particles, plus shoes, pants, jacket, and gloves, so that my own clothes wouldn't take contamination home.

Soon I stood 300 yards from the sarcophagus, listening to the agitated buzz of my radiation meter. If I stayed about two months, I'd receive the five rem of radiation permitted

In the belly of the beast

Two years after the accident, when scientists first peered into the core shaft of Chornobyl No. 4, they were amazed to find it almost empty. Was it possible that hundreds of tons of graphite, uranium fuel, and metal had burned to ash? Exploring the three levels below, they found the answer: There, "frozen" into eerie shapes like stalactites in a nuclear hell, were the hardened remains of a lavalike amalgam known as corium. This indicated a total meltdown of the core, something at first denied by Soviet officials.

Another surprise greeted them: Virtually none of the tons of lead, sand, and boron carbide that had been dropped by helicopter through the roof to quench the fire had found their mark. Most landed on the floor of the central hall, above the core shaft. Once the fire died down, Soviet authorities spared no effort in throwing up a mighty steel-and-concrete sarcophagus (above) around the ruins of the reactor building. But its effectiveness is now in doubt. If the building inside should collapse, it might bring down the sarcophagus, raising a radioactive dust plume over the already poisoned countryside.

1. Sarcophagus
Pieced together in great haste like a giant Erector set of prefabricated steel forms, the 246-foot-high structure was not hermetically sealed, because radiation was too hazardous for welders. Several options for a more secure containment have been studied, though all are beyond the reach of the near-bankrupt Ukrainian government.

2. Water
Water is recycled for spraying to control immense amounts of radioactive dust inside the ruins. This contaminated water — which increases with each rainfall seeping through the leaky roof — poses a growing threat to the groundwater below.

An artist's rendering with the west wall cut away reveals the reactor cavity of unit No. 4. It also shows how the reactor's ruined structure provides questionable physical support for the sarcophagus built around it.

4. Component E
Nicknamed Elena by scientists, the reactor's lid was blown askew by the explosion, its 2,000 tons of steel and concrete riddled with the pipes of broken fuel channels. Its counterpart shield under the core sank 13 feet in the blast.

3. Corium
Melted debris of the reactor core, corium was liquid during a short period of intense heat, then it quickly solidified. Still warm from radioactive heat, it includes about 130 tons of uranium fuel and produces more radioactive dust as it degrades.

ILLUSTRATION BY CHUCK CARTER

yearly for a U. S. nuclear worker. Many Chornobyl workers have received far more; to hold down the cumulative dose, most work only two weeks in a month.

The sarcophagus is the highest structure on this flat landscape, a sore thumb rising gunmetal gray at one end of the long concrete building that houses reactors and turbines. Perhaps it stands out, too, because the landscape has been thoroughly scalped. Cleanup workers not only trucked away contaminated soil for burial in some 800 sites around the zone but even knocked down and interred nearby pine forests killed by radiation.

I came upon a reminder of the desperate cleanup effort—a motor pool posted off-limits with red-and-yellow radiation signs. Armored personnel carriers bore slabs of lead that had helped protect their passengers. From tanks poked not cannon but cranes for lifting "hot" debris. Thousands of tons of such equipment still await burial, one more task in an onerous chain reaction triggered by the accident.

IN THE POWER STATION I was admitted to the control room of reactor No. 3, where white-smocked engineers watched a wall of gauges. It is virtually identical to the control room of No. 4, where other operators triggered the 1986 disaster while reducing reactor power. The operators and their supervisors were blamed, and five went to jail. Two others were among the 32 workers who died.

After the collapse of the Soviet Union, exonerating truths emerged. The graphite-core reactor had, as suspected, serious design flaws. And manuals made no mention of its ironic instability at low power.

Now the rules prohibit operators from dipping below one-quarter power. Some safety improvements have been made—but not enough, contend Western experts, who to no avail have recommended backup water systems for cooling and such fire-protection measures as steel doors.

"It's ridiculous that the reactors are still operating," Valentin Kupniy, deputy zone

■ **Model ghost town, the city of Prypyat—built for Chornobyl personnel—was evacuated two days after the explosion. The previous day residents were sunning themselves along the Prypyat River, even nearer to the ruptured power plant (background). Elsewhere in the 20-mile-radius evacuation zone, police have their hands full pursuing vagrants who invade the homes in some 75 deserted villages.**

■ **The apple is "hot" and the cow's milk may be contaminated, but for two aged returnees to the abandoned village of Kupuvate the comforts of home outweigh the risks of radiation. So far some 700 evacuees, all elderly and most of them women, have returned to the zone. Most supplement deliveries of food with produce and livestock they raise on the polluted land. Authorities tolerate the practice.**

administrator, acknowledged. His hands are tied on that; it's a decision for the Ukrainian government, which last spring announced its determination to shut down Chornobyl—but not until other ways are found to meet the national energy shortage.

New in his job when I met him, Kupniy hoped he could do something about other problems. The first, surely, is inertia. "Years have passed," he said, "and we're just starting to talk about what needs to be done." For example, dikes must be built to block runoff from fields; it carries cesium, albeit in modest quantities, to the Dnieper River, the Kiev drinking supply. To safely bed down No. 4, a super-sarcophagus needs to be built over the present one. Officials hope an international agency such as the World Bank will provide the necessary billion dollars or so.

One day in the zone, I met some "partisans." That's the name given to such people as Nikolai Pavlenko, one of 700 evacuees who have come home. Wrinkled and 71, Nikolai resides in the log house that he built as a young man in the village of Opachychi, 15 miles from ground zero.

Removed to a town many miles distant, he and his wife, Katia, came back three years later. "Everybody wants his own home," Nikolai said simply, as if the matter needed no further explanation. Zone officials have treated the partisans tolerantly, knowing that their families had dwelled for centuries in these now collapsing villages.

Nikolai grows potatoes and cabbages and fishes the streams. "When I need something, I just sort of help myself," he said, nodding toward the empty houses. Radiation? "We don't feel anything," he said.

ON THE OUTSKIRTS of Kiev, in a former tuberculosis sanatorium converted to a hospital for Chornobyl children, I met a "firefly." That's the name thoughtless kids apply to evacuees such as 15-year-old Roman, as if they might glow from radiation.

"I have dizzy spells and headaches," Roman told me. And: "My heart hurts."

"It is stress," Dr. Evgenia Stepanova, the chief pediatrician, said later. "He feels his heart racing. He can't run or play sports."

Roman told me wistfully, "We had a nice apartment in Chornobyl—six rooms. It was beautiful there." Evacuated, his family ended up in a Kiev suburb. "They gave us a three-room apartment. We've been trying to get more space because there are three children. They keep offering lousy apartments on the first floor, where it's cold." His father has ulcers, his mother headaches.

Dr. Stepanova intended to calm Roman's racing heart with tender care, rest, and a nutritious diet. It's about all the hospital can offer.

According to rumors circulating in Kiev, 5,000, even 10,000 Ukrainians have died from various ailments somehow connected with the accident. But because records were carelessly gathered or may not exist, the medical arithmetic can't be summed. Cautious researchers say only: "We don't know how many died."

One of the most tragic consequences evident thus far is a large increase in thyroid cancer in children. In Ukraine, Belarus, and Russia this once extremely rare condition totals more than 300 cases. What other afflictions radiation exposure will bring is a matter of debate. Estimates of the future number of cancer cases range from 5,000 to 20 times that.

I beheld one consequence in a Kiev laboratory under the microscope of Dr. Maria Pilinskaya: chromosomes, magnified a thousand times, broken and mangled. "It is serious," she said. "It indicates risk of leukemia or other cancers."

She discovered this chromosome damage in blood samples from children in seven towns *outside* the zone. All the towns had been sprinkled with radiation, but because the quantity was presumed not to be serious, people were not evacuated. It is impossible to say how many people are so affected. Dr. Pilinskaya could sample only 25 to 30 children per town; most of them were seriously damaged.

For now, according to Western as well as Ukrainian investigators, stress such as afflicts Roman is a more serious concern than cancer or chromosome damage. The psychological and social problems stemming from disrupted

■ Graveyards for radioactive equipment litter the landscape in the evacuation zone. The largest, near the city of Chornobyl, testifies to the gargantuan proportions of the post-accident cleanup. Used by an army of hundreds of thousands of "liquidators," helicopters, trucks, tanks, and bulldozers await burial. Yet even that may not deter scavengers, who have been stripping vehicles for a black market in parts. How many

people died as a result of Chornobyl is a matter of speculation. Though documentation is lacking, the Chornobyl Union, a citizens group, estimates that 5,000 died and 30,000 were disabled, mostly liquidators. But economic costs are known. They include 30,000 square miles of contaminated farmland and billions of dollars in lost productivity and early pensions. The damages consume 15 percent of Ukraine's budget.

lives and radiation phobia lead to real diseases, several researchers told me, including chronic bronchitis, digestive-system problems, and hypertension, and may compromise the immune system. This may explain why, as is reported to be the case, the death rate among irradiated people is far higher than average. By one estimate, 70 percent higher, which indeed would translate into thousands of deaths.

No town I saw was so full of stress—and aching hearts—as Narodychi, whose whitewashed houses stand 45 miles west of ground zero. "Our parents and grandparents built these houses with their own hands," a nurse said. "Let the house be little, but it was ours. It will never be the same anywhere else."

Narodychi is one of the many towns beyond the zone where the local fallout was not considered serious. Then thyroid disorders appeared in children, and Dr. Pilinskaya detected chromosome damage.

So, finally Narodychi was emptying. On a somber winter day I came on a family loading furniture on a truck. "There's no future here," said a woman bringing out dishes. "There's no food to buy, and it's not safe to eat anything you grow."

Across the way, an old man named Sasha, pouring generously from his flask of *samohon*—moonshine—said defiantly: "The only place I'm going is the cemetery."

NO ONE received greater doses of radiation than the first of the liquidators, the Chornobyl cleanup army that may have numbered as many as 750,000 workers. Some got more than 200 rem, enough, physicians say, to cause acute radiation sickness, a breakdown of body systems characterized by nausea, vomiting, and diarrhea. Survivors face an increased risk of cancer.

Other liquidators got little radiation but nevertheless presumed that they were terribly afflicted. In a group of Russian cleanup workers tracked by researchers, stress led to suicides and alcohol abuse. "Everybody told them that because of radiation they couldn't have a normal sex life," a doctor said. "It's a case of bad information causing death."

Dr. Ilya Likhtarev, Ukraine's expert on dosimetry, knows of 3,000 liquidators who received more than the "acceptable" one-time dose of 25 rem, and of 400 who received 75 rem or more. "That multiplies the chances that they will have cancer," he told me.

For most of the liquidators, doses are simply unknown. These include army recruits who did some of the most dangerous work; for example, removing debris from the reactor building roof. "They didn't have radiation badges to record what they received," Dr. Likhtarev said. "So their lieutenants estimated the dosage. But they were under orders not to report a dose of 25 rem, to hide the seriousness. So the dose was recorded as 24.9. It came to be known as the 'administrative dose.'"

Dr. Likhtarev would like to know how these men fared. "But they left the army and went back to Kazakhstan or wherever. Some may have had acute radiation sickness and not known what was wrong." Some may be dead.

Teeth may help scientists construct estimates of the doses that victims received, since radiation causes measurable changes in the enamel. Researchers are collecting teeth from

■ Battered souls line up in Kiev for registration as Chornobyl invalids. Degree of victimhood—1 through 4—and compensation will be determined later. Though medical evidence is sketchy for most applicants, the psychological scars of Chornobyl are undisputed. Struggling with the burdens of economic and political transition, Ukrainians must also bear the costs of an old empire's mistakes.

dentists to evaluate enamel's usefulness as an exposure meter.

"If dose and health can be correlated, it would help in the future," said Armin Weinberg of the Baylor College of Medicine in Texas, a participant in one of the several Chornobyl studies now under way. "We're sure to have more accidents."

AT EASTERTIDE, tradition demands that Ukrainians visit their forebears. So back to the zone, with government permission, just for a day, came busloads of villagers who had been scattered far and wide—people of communities atomized, in more ways than one.

In the hillside cemetery in Opachychi, shawled babushkas placed tokens of remembrance—decorated eggs and Easter cakes—among the crosses. Families sat upon the graves, the traditional communion. They ate chicken and drank samohon, greeted friends and cousins, cursed the atom, and wept.

In late afternoon thunder rumbled and raindrops drilled the earth. The people looked about wistfully, policed the trash, and streamed down from the hill that holds their fathers and mothers. And their hearts. □

Australia's Box Jellyfish

A Killer Down Under

Jetting through water, a box jellyfish looks as harmless as cotton candy. But this scourge of the beach—also called a marine stinger or sea wasp—is earth's most venomous creature. Contact with its tentacles can bring agonizing death within four minutes.

By WILLIAM M. HAMNER

Photographs by DAVID DOUBILET

SHIMMERING IN THE GLOW of flood lamps along the pier, two large ghostly shapes undulated just beneath the surface of the dark sea. Webs of long, almost invisibly thin tentacles swept out behind their box-shaped translucent bodies. We had spotted our quarry: *Chironex fleckeri*, the infamous box jellyfish found in the near-shore waters of Australia and southeastern Asia.

Difficult to see, these cubic phantoms have long cast a dreadful shadow over the sun-drenched beauty of the north Australian coast. Known also as marine stingers or sea wasps, box jellies have killed at least 65 people in the past century.

"*Chironex fleckeri* is without question the most venomous animal on earth," says physician Peter Fenner, marine stinger officer for the Surf Life Saving association of Queensland. "No other animal's venom can kill a human in four minutes or less." Australia's most dangerous snake, the taipan, has enough venom to kill 30 adults, but its bite is not very painful, and it can take several hours for an untreated victim to die. A large box jellyfish, however, has enough venom to kill 60 adults, and the pain of its sting is instant and unbearable. Breathing may quickly become distressed as venom is absorbed into the circulatory and lymphatic systems; in some cases, the heart's pumping slows or stops almost immediately.

I knew *Chironex* were dangerous back in 1977 when my wife and research assistant, Peggy, and I were working as marine biologists at the newly founded Australian Institute of Marine Science in Townsville. Intrigued by box jellies, we collected several juveniles with nets and placed them in an aquarium. We put small live shrimp into the tank for them to eat, but they ignored the prey.

We then tried feeding them by hand—using rubber gloves, of course. Only one, whom we named Charlie, would eat the prawns we placed in its mouth. The other jellies died, while Charlie doubled in size within a month. Charlie died two months later when the aquarium sprang a leak, but the scientific literature indicated that we had accomplished something unique: No one had ever kept a *Chironex* alive in the lab before.

Peggy and I decided to try capturing full-grown *Chironex*. We knew that big jellyfish gathered at night beneath the institute's pier to feed on plankton and small fish attracted to the lights. We also knew catching them would be tricky. The monsters we were after might have a bell, or body, as big as a basketball, only square, and 60 tentacles, each 15 feet long.

With colleague Martin Jones we loaded 55-gallon plastic buckets onto a truck. Wearing long pants, long-sleeved shirts, and gloves taped at the wrists

Close encounters are made safe by a clear plastic carousel of circulating seawater, which the author, at right, helped develop to approximate natural conditions. Martin Jones, director of the Great Barrier Reef Aquarium in Townsville, Queensland, and Peggy Hamner observe as minute shrimp ride the artificial current to end as dinner for a pair of young jellies.

Biologist WILLIAM M. HAMNER heads the Marine Science Center at the University of California, Los Angeles. This is underwater specialist DAVID DOUBILET's 37th article for NATIONAL GEOGRAPHIC.

over our sleeves, we looked like toxic-waste handlers.

Looking down from the pier, we saw two large *Chironex*. We watched, fascinated, as they maneuvered in and out of shadows, never touching the oyster-encrusted pilings that could easily tear their delicate tissue.

We used long-handled nets to prod them into the buckets, which we then lifted onto the dock. By then I had overheated, and I took off my shirt. While we were hoisting the buckets onto the truck, a breeze caught a single tentacle still dangling outside one of the buckets. It gently blew the tentacle against the inside of my upper arm.

I felt as if I had been branded by red-hot steel. My first instinct was to claw at my skin, but I knew that dropping the bucket would be too dangerous. Wincing with pain, I managed to help lift the bucket onto the truck. Then I examined the damage: a fiery welt, braided with the characteristic bands of the box jelly's tentacle.

I was lucky. Only about an inch of tentacle had stuck to my arm. It takes ten feet or more to deliver a fatal dose of box jelly venom. An inch was enough for me. A hundred times that level of pain was unimaginable.

IN RETROSPECT our night at the pier seems to have been worth the price of a painful sting. Before leaving Australia, we were able to advise two newly arrived researchers at

Sinuous waterways near Townsville, Queensland, serve as summer spawning grounds for adults. In spring the young head seaward to troll for shrimp and other prey in coastal waters. When fully grown, *Chironex fleckeri* (opposite) may stretch 15 feet with a comet tail of as many as 60 tentacles streaming from its bell. Strong and nimble swimmers, jellies can zip along in bursts of up to five feet per second.

James Cook University of North Queensland, Robert Hartwick and Masashi Yamaguchi, how and where to capture adult *Chironex*. They then conducted pioneering studies of box jellyfish.

Yamaguchi and Hartwick wanted to document the life stages of *Chironex*. Other jellyfish begin life as mobile little balls of cells called planulae, which settle on rocks or other hard surfaces and transform into polyps—tiny organisms with a crown of tentacles. But in 1977 no one had ever seen either *Chironex* planulae or polyps. Yamaguchi and Hartwick didn't know what to look for.

However, the night we captured the adult *Chironex* we had noticed that the stress caused them to release their sperm and eggs into the water in the buckets. Yamaguchi and Hartwick theorized that if they mixed water from a bucket containing sperm with one containing eggs, they would get fertilized *Chironex* eggs. They might then learn what the planulae and polyps actually looked like.

The biologists soon had tanks, jars, and plastic dishes brimming with planulae. However, the organisms died soon after transforming into microscopic polyps.

"We knew that the planulae needed to attach to a hard surface," says Hartwick. "We offered them rock, mollusk shells, coral, and mangrove roots, but they rejected them all and died." Then Hartwick and Yamaguchi happened to look at the bottom of a plastic container in one tank. There, for reasons they still can't explain, polyps were thriving.

Now that the men knew what the juvenile forms of *Chironex* looked like, the next step was to find them in the wild. That proved laborious, because of their small size and because

Tortuous welts left by stings mark the trunk of a woman (below) and a girl's legs. Both survived, though they were scarred for life.

Box jellyfish are about 95 percent water—practically invisible in turbid coastal waters. During the summer, says emergency doctor John L. Holmes, "it is quite unsafe to swim in the ocean in tropical northern Australia"—something travel brochures do not stress. Swimmers are urged to use

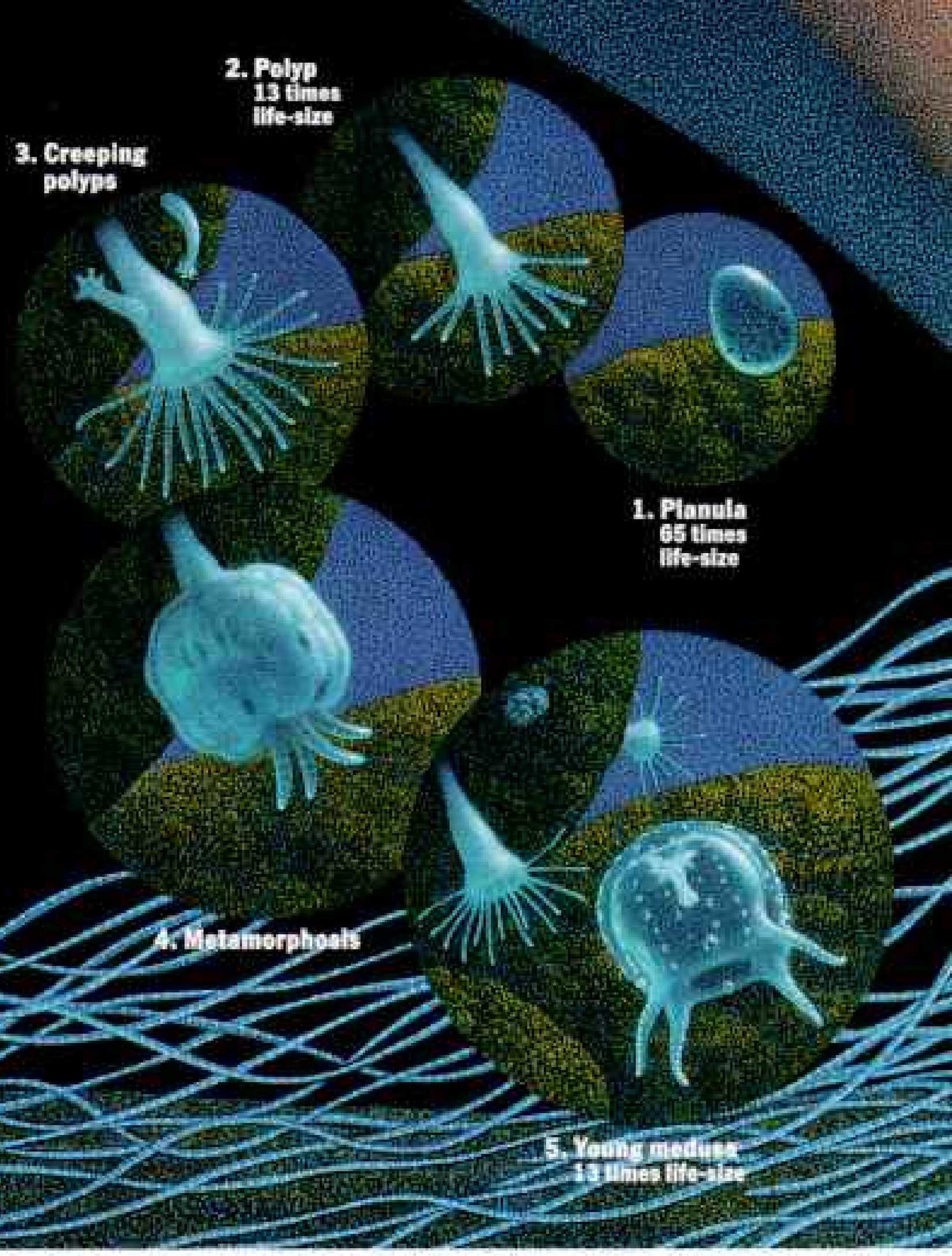
PETER FENNEN (TOP); SURF LIFE SAVING QUEENSLAND (ABOVE)

only fenced "stinger resistant" areas and to wear protective clothing such as full-body Lycra suits. In fact, fabric as sheer as panty hose shields the skin.

A Cairns newspaper reported on a swimmer who paid a steep price for going outside an enclosure: stings on his neck, chest, and back and two nights in the hospital. Stingers have killed at least 65 people over the past century. An antivenom developed in 1970 is credited with saving lives.

Ghostly Assassins

A life span of only months begins after ova and sperm unite. A planula (1) develops into a polyp (2, and photograph below) that attaches to the underside of rock. Reproducing asexually, creeping polyps (3) shed new polyps, here resembling arms. Final shape comes with metamorphosis (4) into a young medusa (5), from which an adult (6) emerges.



no one knew where breeding occurred. Since *Chironex* medusae appear only in the Australian summer, some biologists thought they migrated south from New Guinea. However, Hartwick suspected they might spawn between the mainland and the Great Barrier Reef, some 40 miles offshore.

"We went out month after month collecting plankton," he says, "sifting through millions of cubic meters of seawater." They found that the youngest and smallest medusae were closest to the mainland, indicating that spawning grounds were nearby.

Later, Hartwick found small *Chironex* medusae three or four miles into such estuaries and streams as Alligator Creek. In

ROBERT F. HARTWICK, MAGNIFIED 22 TIMES

1980 he began collecting rocks, mollusk shells, and pieces of mangrove roots to examine for polyps under a microscope. For six years he searched in vain.

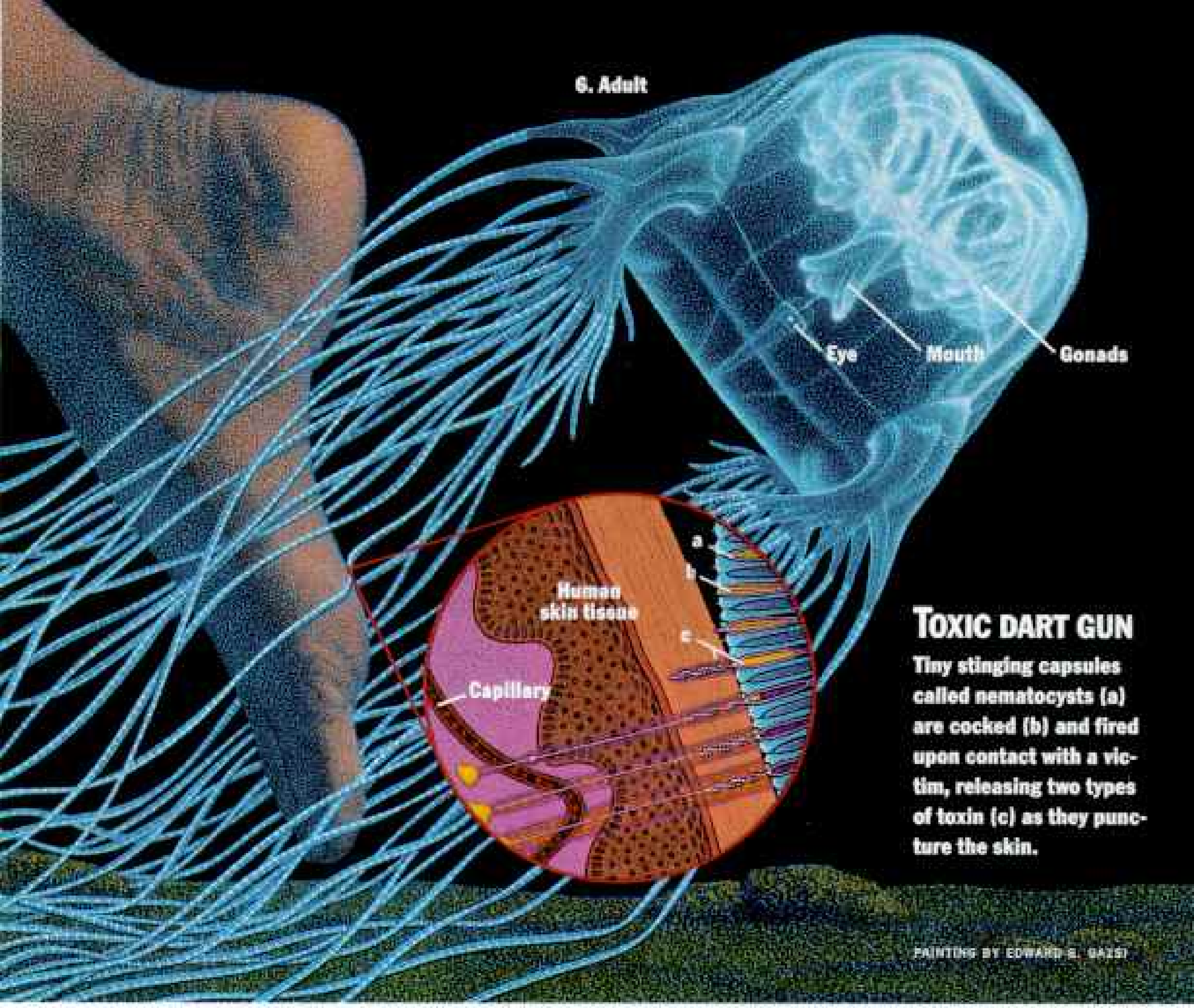
"We looked at thousands of rocks from 14 rivers," says Hartwick, "sometimes taking as long as four hours to carefully examine a four-inch rock. The rocks were typically covered with a dense growth of vegetation and tiny animals. It was like searching for one small shrub in a forest."

One day an assistant came into Hartwick's office, eyes gleaming. "Come take a look," he said.

There, on a rock, Hartwick saw polyps that looked just like *Chironex*.

"I tried not to get too excited," recalls Hartwick. "Polyps often look alike. We had to see what these grew into."

Over the next 12 days, the typical time for box jelly metamorphosis, Hartwick and his team watched eagerly as each



TOXIC DART GUN

Tiny stinging capsules called nematocysts (a) are cocked (b) and fired upon contact with a victim, releasing two types of toxin (c) as they puncture the skin.

PAINTING BY EDWARD G. GAZSI

step from polyp to medusa matched what they expected. Finally, the medusae emerged, and they were unquestionably tiny box jellies.

THANKS TO Hartwick and Yamaguchi's work, we can now describe the entire life cycle of the box jelly. Adults aggregate in river mouths and estuaries in late summer to spawn and then die. The resulting planulae settle onto the bottom, where in the

Puffs of venom erupt from wispy nematocysts triggered by alcohol in a laboratory. Contracting like a coil, a tentacle gains purchase on a hapless shrimp.

Australia's Box Jellyfish

Eerie as a movie monster, a marine stinger peers through one of its four eye groups, at center. Eye groups serve each quadrant of the creature's box-shaped bell, which inspired the species' most common name.

Magnification (right)

DAVID DOUBILET AND ZOCI FLORIAN; SEM

shows a lens and cornea. But researchers have yet to fathom how the creature can see without a brain.

However they sense their prey, box jellyfish do not attack. Fragile and gelatinous, they wait until something blunders into them.

fall they transform into polyps and colonize the undersides of stones, creeping along to find a suitable spot to anchor. During this time, new polyps may sprout from existing polyps. In the spring the polyps become little medusae, migrating seaward before monsoon rains set in. At sea they feed on prawns and fish, but their favorite food is a small shrimp that schools close to shore—along the same sandy beaches that Australians find so attractive in the summer.

And therein lies the problem. *Chironex* do not intentionally sting humans, of course, but simply react when their tentacles are brushed. Jellyfish tentacles have specialized stinger capsules called nematocysts, each of which has a mechanical trigger. To fire, however, the nematocysts must be stimulated chemically. That stimulation comes from chemicals found on the surface of fish, shellfish, and, unfortunately, humans.

The slowly pulsing translucent bells are hard enough to see as the medusae troll for prey in northern Australia's murky coastal waters; their tentacles are even harder to see. Fifteen feet long and only a quarter inch thick, they stream behind the bell like invisible fishing lines. In fact, not until 1956 was the species *Chironex fleckeri* actually described and identified as the creature that inflicted such agony. Stories abounded of swimmers running from the water screaming, tearing at lesions on their skin but never having seen their assailant.

Fortunately for tourism, box jellies do not live on the Great Barrier Reef, where about a million visitors swim throughout the year. Nor do box jellies haunt the beaches of Australia's Gold or Sunshine Coasts near Brisbane. But summer beachgoers have had to adjust their behavior to the presence of the lethal jellyfish along the shores north of the Tropic of Capricorn, which passes near the city of Rockhampton in the northeastern state of Queensland.

When people do bathe along vulnerable beaches, they should either swim in safely netted areas or wear protective clothing. Entrants in surfing competitions have been known to wear two pairs of panty hose—one covering their legs, and the other upside down, with the wearer's arms thrust through the pantyhose legs and the head poking through a hole in the seat.

How can the ultrathin pantyhose fabric protect against such potent venom? The stinger capsules are too short to puncture skin covered by the hose. That's fortunate, because although each nematocyst injects only a microdrop of venom, a single tentacle contains millions of the deadly capsules.

"That's one reason why *Chironex* stings can be so difficult to treat," explained marine stinger officer Peter Fenner. "Snakes and spiders generally bite only once, in a single spot, but box jelly venom enters a victim over a large area. Fortunately we now have an antivenom."

The antivenom was developed 24 years ago by scientists at Australia's Commonwealth Serum Laboratories, who injected sheep with nonfatal doses of venom. The sheep then produced antibodies that can be used to manufacture antivenom. Medical personnel in coastal regions of the Northern Territory and northern Queensland carry the antivenom.

"It can be very effective," said Fenner of the antivenom, which is either injected into muscles or administered intravenously. "Normal breathing often begins almost immediately, and pain relief usually occurs within minutes. Later scarring is frequently reduced."

I met Fenner in the Queensland town of Mackay in 1993, after Peggy and I got the chance to go back to Australia to resume research on box jellies. She and I had talked many times of returning to study these animals. Then one day the phone rang. Our former colleague Martin Jones, director of the Great Barrier Reef Aquarium in Townsville, had an irresistible offer. He had managed to keep a box jelly alive for nine months in an exhibit. It had died, but he had procured funds through James Cook University and two local Lions Clubs for a *Chironex* research program. Could we come down and help start the project?

WE WERE EAGER to investigate and photograph the predatory and feeding behavior of *Chironex* medusae, but we faced serious problems. The animals appear and disappear unpredictably in the water. Studying them in nature would be impractical. Moreover, as we'd learned, most box jellies won't eat in captivity.

However, I had recently helped develop a new type of aquarium, called a planktonkreisel—from the German for plankton carousel—for the Monterey Bay Aquarium in California. The planktonkreisel rotates water in a way that prevents jellyfish from becoming trapped in corners or stuck on the drains. The Monterey aquarium's planktonkreisels are spectacularly successful; its jellyfish thrive. The aquarium's curators adapted their blueprints for us, and when we arrived in Townsville, a new planktonkreisel was ready.

We captured several box jellies and placed them in the new aquarium. Immediately they began to swim in the circular current with their tentacles

Lethal lasso snags a banana prawn and draws the meal mouthward. The victim's carapace was instantly punctured by the jelly's stinger capsules, unleashing a multipronged arsenal of toxins that attack breathing and blood cells.

stretched out behind them—something we had never seen in still-water tanks.

We put live shrimp in the tank, and one of the *Chironex*'s tentacles soon touched a spiny banana prawn, which died instantly. Entangled in tentacles, the shrimp was reeled in close to the box jelly's pedalium, a feeding appendage that lifted the shrimp up to the medusa's reaching mouth. We had at last managed to create an environment in which box jellies would demonstrate how they earned a living.

We quickly appreciated why *Chironex* needs to be so lethal. Prey such as banana prawns are covered with sharp spines. If the prawn were eaten alive, just one flip of its powerful tail would tear the jelly's delicate tissue to pieces. Far better to kill quickly.

One aspect of *Chironex* behavior caught Peggy's attention. She realized that jellyfish in a large holding tank swam away from her when the room lights were bright and she wore dark clothes. "I have a strange feeling these jellies see me coming and deliberately get out of the way," she told me.

Such behavior in an animal as simple as a jellyfish was certainly unlikely. It's true that box jellyfish have structures that greatly resemble the eyes of vertebrates; could their nervous system be complex enough, we wondered, to process visual information?

Convinced that the box jellies were somehow seeing her, Peggy sealed off the aquarium room so that no light penetrated from the outside. Then she and Martin began a series of experiments in which she presented the jellies with various targets, painted black to contrast with the white wall of the tank. Each time she displayed the targets, the jellyfish turned away. Even a small target half an inch wide was enough to send them pulsing in the opposite direction.

Peggy's careful experiments demonstrated that box jellies can see very well. No one has any idea yet how they do it.

DURING ONE of our last days in Queensland in 1993 the watchman at the Australian Institute of Marine Science called to report that he'd spotted four box jellies beneath the same pier where the dangling tentacle had stung me

in 1977. We donned our protective suits, loaded the truck with buckets, and drove out at dusk. Almost as soon as we began to search the waters, a shark glided into view among the pilings. We decided not to wade in to catch our quarry.

Soon three large green turtles, each nearly three feet long, appeared, slowly swimming back and forth in the pools of light shining from the pier. Something about the way those turtles cruised through the water made me wonder if they might be looking for jellyfish.

I didn't wonder long. From the darkness came a box jelly the size of a grapefruit, languidly pulsing toward the pier. We watched it dodge the dangerous pilings. This once perplexing behavior now excited us, since Peggy and Martin had proved that *Chironex* can easily see objects the size of pilings.

Then, as I prepared to lower my net, out from beneath the pier came the three turtles. The box jelly didn't have a chance. The fastest of the turtles chased it down and consumed it in two quick bites.

The sight was startling. This creature that can kill in an instant was being casually dined on, tentacles and all, by an enemy obviously immune to its defenses. During the next hour two more box jellies appeared. The turtles finished each one off before we could even pick up our nets.

How did the sea turtles do it? No one knows exactly. Perhaps there is some protection afforded by the lining of their digestive system—which may also be what allows them to eat glass sponges with ease. Sea turtles have been found with as much as a pound of the sponges' sharp siliceous spicules in their digestive systems. There may be another explanation, one that science has not yet found.

But now it was time to pack our gear and go home. I lingered for a moment, hoping to catch a last glimpse of a box jelly and marveling at how much we had learned about *Chironex* since the days of feeding Charlie by hand 17 years earlier. Yet we had just discovered that this most venomous of creatures faces its own vulnerabilities. Once again, as it has so often, the unseen life beneath the dark sea had enlightened us in an unexpected way. □

Cast-iron gut may help the hawksbill turtle snack with impunity. Still, the box jelly's stinging capsules are, says biologist Robert Hartwick, "perhaps the most compact, complex, and effective weapons developed by any animal other than man."

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Forum

The Everglades

As a National Park Service ranger who spent five years in the Everglades, I read Alan Mairson's article (April 1994) with mixed emotions. The Everglades is indeed dying, and any voice telling the world that this phenomenal landscape needs to be saved is worth listening to. I only wish Mairson had been able to fall in love with the place as so many people have. He should sit on the Anhinga Trail and listen to exclamations of wonder by visitors from around the world seeing their first alligator in the wild. A wilderness is not supposed to be convenient. Getting mosquito bites, torn pants, and the like are part of the price you pay for admission. While diminished a hundredfold from what it once was, the show is still astonishing.

BILL O'DONNELL
Eminence, Missouri

Wouldn't it be more accurate to describe the persons who shot holes in abandoned automobiles as "vandals" rather than "gun lovers"?

FREDERICK R. SPENCER
Anderson, Indiana

In discussing Archie Jones and the Florida tree snails, you could have referred to another excellent article, "Tree Snails, Gems of the Everglades," in the March 1965 issue. It highlighted the long-term work of Jones, then a Miami businessman, and three other snail collectors turned conservationists to protect the snails.

PIERRE HERANT
La Gaude, France

There is much more to South Florida than Everglades National Park. The diversion of water from the park has produced many benefits for mankind. You would do a great service to publish an article showing these benefits.

S. C. FRY
Clewiston, Florida

After visiting the Everglades in January for the first time, I got involved in studying it at the State University of New York at Buffalo, where I am a senior in environmental studies. The more I learned, the more I grew to love the area. I am now looking into attending graduate school in environmental management at the University of Miami. Your article gave worldwide attention to this ecosystem on its last leg. Although it will be an uphill

battle to save it. I am one individual who is ready to head down to the war zone and fight.

JAMES R. SCHUMM
Buffalo, New York

My son and I had just returned from the Everglades when the April issue arrived. It was a beautiful experience to travel the Snake Bight and Mahogany Trails; we toured for 50 miles into the maze of waterways. Florida should do some priority thinking; it has a precious treasure that needs to be saved. It's not boring; it's just wonderful.

CLEO A. NELSON
Council Bluffs, Iowa

Kamchatka

What a contrast your photographs of Kamchatka show. The trophy hunter who kills the bear for sport wants only the skull and skin and is concerned about proving the animal's size. The indigenous people kill the reindeer for survival, eat and use its parts, and show respect for the animal even in death. Yet it is the trophy hunter we call civilized.

JULIE MOSS SCANDORA
Seattle, Washington

An astounding footnote to your article on Kamchatka is that its 30 active volcanoes emit—in addition to the typical sulfur dioxide, hydrogen fluoride, and hydrogen chloride—a number of CFCs and chemicals containing chlorine, including chloroform, carbon tetrachloride, and Freon 11 and 12, formerly thought to result only from human action. These chemicals are also produced by the Santiaguito volcano of Guatemala. Such natural chlorine compounds are apparently produced in the eruption zone by the combustion of vegetation, sediments, or fossil soils in the presence of chloride and fluoride mineral deposits. The extent to which these natural chlorines contribute to the global picture remains to be seen.

GORDON W. GRIBBLE
Professor of Chemistry, Dartmouth College
Hanover, New Hampshire

Bryan Hodgson's article reinforced my appreciation for a very special journey last August to visit a young pen pal in Kamchatka. Arriving in Petropavlovsk, I felt as if I had walked into the 1940s. My hosts lived in one of the countless look-alike apartments, at times without hot water. Their neighborhood was bleak, the streets dirty, and the air polluted. But the view of the snowcapped volcano from the apartment was breathtaking, and my joy in seeing my friends distracted me from the grim surroundings. We visited the Valley of the Geysers, the impressive cultural museum, and dachas outside the city. I was invited to dinners to welcome the American lady and met warm, generous people who have adapted to a life of shortages and inconveniences unknown to my friends or me.

CAROL ANN WALTERS
Devon, Pennsylvania

Riddle of the *Lusitania*

Thank you, thank you. For over 40 years my husband has scoffed at my story of how my great-aunt Josephine Burnside was sucked into a funnel of the *Lusitania* and then was blown out again to land on a raft and later be picked up (page 73). Aunt Josie was the daughter of Timothy Eaton, the founder of the Canadian department-store chain. She had lost a son early in World War I, and she and her daughter were traveling overseas to visit his grave. The daughter did not survive the sinking, but Aunt Josie lived into the 1940s.

PAULINE WELCH
Toronto, Ontario

I take exception to Robert Ballard's comment linking the *Titanic* and *Lusitania* and "suggesting a relative weakness amidships in this class of vessel." The two were not sister ships of a class. They were built to different designs, by different owners, and in different countries, Ireland and Scotland. *Titanic* was about a hundred feet longer and of one-third more displacement. Both ships broke up after initial damage while en route to or hitting bottom. Where long lengths of ship are virtually unsupported, the breaking up of the hull is not uncommon. Hulls are not designed to withstand this type of stress.

TERRY TILTON
San Diego, California

A prudent captain would have held at least one lifeboat drill with passengers and crew participating and lifeboats lowered. The radial lifeboat davits depicted on page 73 require intensive skill and training. Also, passengers should have had lifejackets on when transiting the crucial death zone. And why was the 25-knot ship loafing at 18 knots in this critical area, having been warned of three previous sinkings in three days?

HENRY A. SHAVE
Peach Bottom, Pennsylvania

John Wesley Powell

Peter Miller's "Vision for the West" was a pleasure to read. It has given me the opportunity to share my copy of Powell's diary *The Exploration of the Colorado River and Its Canyons* (available through Penguin Books) with my friends. As the Major writes, "The wonders of the Grand Canyon cannot be adequately represented in symbols of speech, nor by speech itself." A big thank-you to Bruce Dale for his marvelous photographs.

PAT KENNEMER-KETTELL
Pekin, Illinois

The photograph at Crouse Canyon, Utah (pages 96-7), is coupled with a Powell quote: "Hills laugh with delight as burgeoning bloom is spread in the sunlight." I am reasonably certain that the "bloom" we see consists of floating, parachute-like seedlings airborne after purple buds of Canada thistle ripen and burst. This noxious weed, imported from England, is one of several that are taking over land in the intermontane West. I rather think that the hills shuddered at the invasion. Powell certainly never saw the same sight.

GLEN E. FULLER
Salt Lake City, Utah

Powell was not the first white man to explore the Grand Canyon. In 1854 Brigham Young called Jacob Hamblin to be a missionary to the Indians in that area. On November 7, 1858, he crossed the Colorado at a place believed to have been used by Father Escalante in 1776 and by Spanish trader Maurice Arze in 1813. Subsequently Hamblin crossed the canyon many times, explored freshwater sites, located different approaches, and helped establish two ferry operations. According to one account Powell sought out Hamblin for advice and invited him on his 1869 trip. After the trip the two became fast friends and shared adventures exploring the canyon, visiting Indian tribes, and negotiating peace treaties. Hamblin introduced Powell to the area that became Zion National Park and worked for Powell as an Indian agent. See *Jacob Hamblin, the Peacemaker*, by Pearson H. Corbett (Deseret Book Company, 1952).

GERALD L. GIBSON
Yuma, Arizona

While Jacob Hamblin did explore much of the region, Powell led the first white expedition to cover the entire length of the Grand Canyon.

Earth Almanac

So what's new? Not the idea for Ed Show's Bug Vac in the April Earth Almanac. It was new when *Popular Mechanics* featured it in their June 1945 issue. Their model could be used in conjunction with a cultivator, and the collected insects could be fed to poultry. After 50 years of bad chemistry, we need more people like Ed to invent and revitalize sensible technologies.

JACK BARBETT
Brooklin, Maine

Geographica

The Fender's blue butterfly (April 1994) is found in the McDonald Research Forest, managed by the College of Forestry of Oregon State University. The college helped sponsor the research that identified the extent of the population and its habitat requirements. We believe we can demonstrate active forest management techniques while maintaining the ecological viability of species.

DAVID H. LYSNE
Oregon State University Research Forests
Corvallis, Oregon

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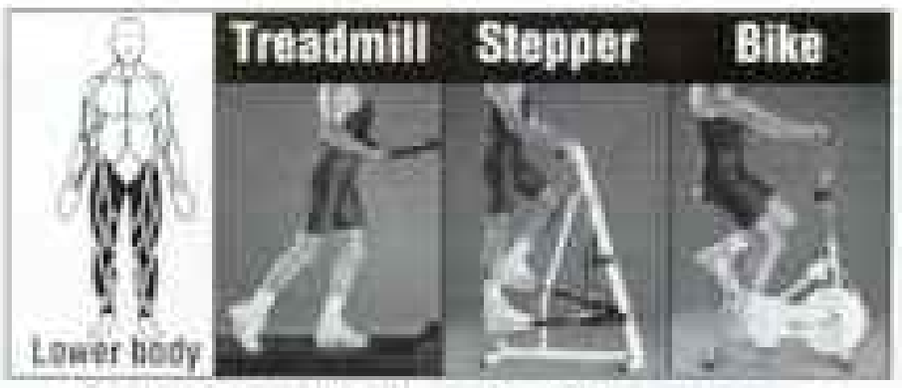

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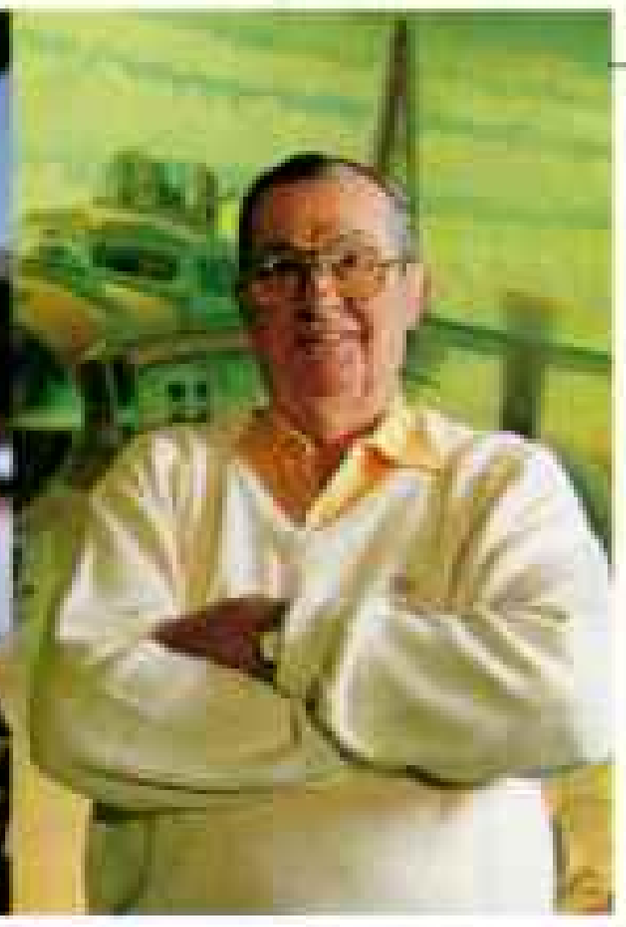

GERALD R. MESSNER COLLECTION (TOP LEFT); IRA BLOCK

Locating "Missing" Fliers of Eighth Air Force

Last March Howard Slaton, a B-24 pilot in World War II, received a surprising phone call at his Potomac, Maryland, home. His copilot Larry Riesen, of Cedarburg, Wisconsin, shouted, "Skipper, I'm sure that's you in the new NATIONAL GEOGRAPHIC!"

It was—appearing in an article on the Eighth Air Force, with four other airmen, all unidentified.

Now they have been. Slaton (above), a 1942 West Point graduate who flew with the 458th Bomb Group, recognized two others as his bombardier Ross Messner from Nebraska (upper right on page 94 of the March issue) and his flight engineer David Kerr of Bountiful, Utah (lower left). They flew 31 missions, striking industrial targets. "You always, always had flak," Slaton recalls. "It would come up so fast and furious, the smoke looked solid enough to walk on. But I never had anyone wounded, thank the Lord." All survived the war; Messner died in 1989. Slaton retired as an Air Force colonel in 1970.

Several readers noticed that the two airmen pictured together bore a striking resemblance. Don and John Echols (above right) are, in fact, identical twins, who wrote from their respective homes in Rainbow City and Vestavia Hills, Alabama. After high school in El Monte, California, they enlisted and served together in the 458th Bomb Group. They had flown six missions together as gunners on B-24s when Don, at left, was severely wounded by flak over Belgium. He returned to the U. S.; John flew 20 more missions. After the war the brothers moved to Alabama, completed college, and spent long careers with the same corporation before retiring.

It was rare for brothers, much less twins, to fly together, John says. "I asked to be on another crew, but we were so short of gunners, I was told I'd have to find my own replacement. That meant I had to fly."

STOMOLOPHUS MELEAGRIS; RONALD J. LARSON

Is There Gold in the Gulf's Jellyfish?

Fishermen of the Florida Panhandle dread late summer. There's not much out in the Gulf of Mexico then except shrimp and cannonball jellyfish that arrive in prodigious quantities, clogging shrimp nets. But what if idle fishermen could harvest the pests for export to Asia, where dried jellyfish ranks as a delicacy? That's the thinking behind a project conducted by the Florida Bureau of Seafood and Aquaculture. Last year on test runs a trawler hauled in tons of the mild stingers, which reach eight inches in diameter, dried and pressed them, and sent samples to Asia. The early verdict: The Gulf product is properly white and crunchy, but so far too expensive to process. Researchers go out again this month to hone their processing techniques on this plentiful marine resource.

National Geographic, August 1994

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Geographica

DAVID DOUBILET

FUTORA TOSHIRO, NATURE PRODUCTION

Harbor of Death, Now a Diver's Eden

Over the years the Japanese village of Futo gained notoriety for a grisly roundup: Thousands of dolphins penned in nets were slaughtered for meat. In the last decade the dolphin population crashed, and fishermen feared for their economic future (GEOGRAPHIC, September 1992).

Now Futo has a new identity as a booming diving resort in a fish-watcher's paradise. Scuba divers in growing numbers visit the small, man-made port on the Izu Peninsula, 65 miles southwest of Tokyo, to see spectacular marine life: dragonets, lionfish, large squid, and sea anemones. Some 25,000 divers jammed the resort last year, filling new hotels and restaurants. Their daily dive fees contribute a quarter of a million dollars to the local economy each year.

"Futo is one of the most beautiful places in the world for divers," declares underwater photographer Koji Nakamura, who lives near the harbor village and has dived at locations around the globe. The Kuroshio current keeps the water off the east coast of Japan warm and exceptionally clear. Japanese sport divers—counted at 400,000 and rising—find Futo a harbor of life. "Futo's fishermen have discovered that the real money is in people," says Nakamura.

SUSIE BRIMBERG

Grand Rebirth for a Regal Indian Woman

Three centuries after her death, and more than two decades after her grave was found, a young woman from North Carolina's Saura tribe is again a major figure. Artists, archaeologists, forensic sculptors, and beadworkers joined forces to mold a true-to-life body cast and then fashion an elaborate ceremonial cowl and dress like those that covered her in the grave. The Sauratown Woman (left) is a highlight of the new home of the North Carolina Museum of History in Raleigh, which opened in April.

In 1972 University of North Carolina archaeologists chased away looters digging up a burial site near Walnut Cove. The scientists found the woman's remains with fragments of her deerskin dress and hood, brass bells, and thousands of glass trading beads. The woman, age 18 to 21, may have been her community's highest ranking female, says state archaeologist Billy Oliver. Grave goods, including a salver-plated spoon and two pairs of iron scissors, date from 1680 to 1720.

A small Siouan-speaking group, the Saura lived in southern Virginia and the North Carolina Piedmont region until European expansion forced them to disperse by 1725, Oliver says.

A Dietary Aid for Northwest Pigeons

Like clockwork, band-tailed pigeons appear at mineral-rich springs in the forests of the Pacific Northwest at the same time each summer. Males arrive to sip, then fly to their nests to spell females so they too can drink.

Recently scientists have figured out why. All pigeons produce a calcium-rich cottage-cheese-like substance called pigeon milk to feed their young. Most band-tailed pigeons eat seeds and nuts, but those in this region eat mostly berries, which are woefully short of calcium.

ROBIN MATHEWSON

"We used to think visits to mineral springs had something to do with migration," says Robert Jarvis, an Oregon State University wildlife ecologist. "But we've learned they're related to the need for calcium during the nesting season."

—BORIS WEINTRAUB

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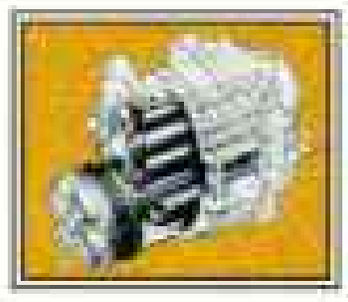
of this engineering marvel lies a supercharged engine that ingeniously delivers 

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On Television

Family Lives of the Night Hunters

Out of the darkness come lions to drink from the waters of Savuti (above), part of 4,080-square-mile Chobe National Park in Botswana and home to Beverly and Dereck Joubert for most of the past 13 years. The Jouberts, who filmed three National Geographic Specials in northern Botswana, open EXPLORER's new season with "Lions of Darkness"—a two-part look at life in a lion pride.

In the afternoon lions drowse, rarely lifting a paw other than to bat a pesky cub (right). At night they prowl their realm, and the Jouberts move with them in a four-wheel-drive vehicle. With lights modified to soften their intensity, the Jouberts record scenes seldom witnessed by daytime visitors to Savuti.

"Lions of Darkness" begins with three young males ousting

BEVERLY JOUBERT (BOTH)

an aging male from his dominant place in the pride. Having won the prize—eight young lionesses—the three set about lion business. They roar, mark territory, protect the pride, fend off males who would supplant them, and subdue the females.

Lions are the most social of all great cats; when pride females give birth—usually within days of one another—they nurse and rear their young communally. But occasionally a cub is born later. The Jouberts focus on one such cub, called Tau, who has trouble keeping up with the others—especially after his mother is killed.

The cub wanders alone for five nights. "We found ourselves caught up in our emotions," says Dereck about the temptation to intervene. "Yet we were resolute in our determination to let nature prevail."

The Jouberts capture timeless rituals such as the chase and the feeding frenzy. They also convey a sense of the cycle of generations, a saga that plays out its most dramatic moments under a moonless Savuti night.

EXPLORER's "Lions of Darkness" airs August 21 and 28 at 9 p.m. ET on TBS Superstation.

Earth Almanac

PAINTING BY WILLIAM H. BOND (BELOW); NATALIE B. FORES

New Chemical Digs Deep Into *Exxon Valdez* Oil

More than five years ago the *Exxon Valdez* plowed into a reef in Alaska's Prince William Sound and coated some 1,500 miles of shoreline with oil (NATIONAL GEOGRAPHIC, January 1990). Despite an expensive cleanup, after-effects continue to harm wildlife and commercial fisheries, critics charge. A civil suit filed against Exxon by fishermen, property owners, and natives that may total billions of dollars is now in court.

On some beaches oil remains buried deep among cobbles and boulders. But a new weapon called PES-51 is exhuming that stubborn subsurface goo. A biodegradable hydrocarbon cleaner, PES-51 releases oil molecules from both porous and nonporous surfaces, causing the oil to float on water.

"We got about 150 gallons of oily liquid out of the ground," says Steve Rog, the environmental geologist who oversaw the first test of the chemical last year at Sleepy Bay on Latouche, an island hit hard in 1989.

There the chemical was injected into the rocky beach (above), which was then flushed with seawater. The oil was collected by skimmers and booms.

PES-51 may also keep future oil spills from adhering to beaches, Rog says. Sprayed on before a slick hits, it would create a nonstick film, allowing the oil to slide back into the sea.

Grizzlies Feast on a Mountain of Moths

A lowly insect—the army cutworm moth—is one of the most important foods for a third of the some 300 grizzly bears in the Yellowstone National Park area. Each summer millions of moths migrate from the Great Plains to peaks above 10,000 feet to feed on wildflower nectar and shelter in the rocky slopes.

At lower elevations during this time bears feed on roots, clover, grasses, and a few insects. But others have learned to climb to a banquet in the sky, digging the moth morsels out of the rocks.

"One bear may eat 20,000 moths a day," says Steve French. Among several researchers studying this popular topic, Steve and his wife, Marilynn, have investigated the behavior for seven years. "The moths can be 80 percent fat and 20 percent protein," Steve reports. "Some bears feed on them for eight hours a day."

Until recently such alpine areas had not been considered important grizzly habitat. French worries because many lie outside the park in national forests and are vulnerable to oil and gas drilling, mining, and development as ski resorts.

"Now we may have to protect those alpine sites," he says.

National Geographic, August 1994

ANNIE GRIFFITHS BELT

Drink-box Makers Win Recycling Flap

Kids love to curl up with those handy, airtight little packages called drink boxes. They preserve juice, milk, and other liquids for months without refrigeration. But for several years environmentalists have charged that the drink boxes are too hard to recycle. The makers not only have denied this but also have successfully counterattacked.

In 1990 Maine became the first state to ban the sale of most drink boxes. Stung, manufacturers fought back, lobbying with pilot programs in schools designed to show that recycling the boxes is feasible. Last April the industry won a major victory when Maine's governor, John McKernan, Jr., repealed the ban.

Multilayered sandwiches of paper, plastic, and aluminum, the boxes must be "hydropulped"—churned in water—to separate elements for recycling. Opponents still contend the process is too expensive. Yet all the furor has been largely symbolic. Drink boxes contribute a minuscule .03 percent of the nation's municipal waste stream.

Environmental Swan Song—a Sour Note

The swans of Berwick upon Tweed in England's far north are paying a price for the cleanup of the River Tweed. The process depleted their favorite food source—grain and husks from a barley malting plant.

In January 1993 the National Rivers Authority ordered the malting plant to improve its processing and reduce the effluent—containing both barley, which the swans eat, and oil residue—that was entering the river.

At times the town hosts as many as 800 mute swans. To supplement the birds' diet during last year's severe winter, volunteers like Liz Wills (left) fed the swans donated grain and bread.

"The swans looked absolutely miserable," says veterinarian David Rollo. "They were going into people's gardens for food."

PATRICK WARD

An Ecosystem's Fate Cast to the Wind

Was it only spiny lobsters that were vanishing from the Northwestern Hawaiian Islands in 1990? After verifying the low lobster reports, biologist Jeffrey Polovina discovered more clues in a detective story: Seabirds, Hawaiian monk seals, reef fish, and even plankton also were declining. "At first," he says, "we thought the entire ecosystem was crashing."

PANULIRUS MARGINATUS, DAVE B. FLEETHAM, PACIFIC STOCK

Then Polovina investigated a weather system called the Aleutian low that each winter brings rain and strong winds to Hawaii. He found that from 1977 to 1988 the low was unusually strong. Its turbulence had vigorously mixed nutrients in the sea, benefiting birds and marine life. Populations rose.

But by 1990 the low's intensity had diminished. Nutrient levels fell, as did populations. So instead of catastrophe, life is just returning to normal.

—JOHN L. ELIOT

National Geographic, August 1994

On Assignment

GERD LUDWIG

Navigating with a Geiger counter, photographer GERD LUDWIG searched for a uranium-waste lagoon rumored to be in Sillamäe, Estonia, for this month's article on pollution in the former Soviet Union. "Local officials insisted that this place didn't exist," remembers Gerd. "There were no signs, no fences, no gates, nothing to show the direction. Only the ticking of the Geiger counter told us when we were getting close."

Before photographing the radioactive shore, Gerd (above, at right) and his assistant Maxim Kuznetsov donned respirators, safety coveralls, rubber gloves, and boots.

"We always brought lots of our own protective gear," says Gerd, who traveled through nine former Soviet republics for the article, "but in many places, we were asked not to wear it, since the people working on the sites didn't have any themselves. You walk a thin line: You want to be safe but you also need people's trust and cooperation to get the pictures."

At Chornobyl's damaged nuclear plant, officials did issue the Los Angeles-based photographer some Ukrainian-style radiation protection—a hard hat and a white cotton lab suit. Tested for radiation exposure upon his return to the United States, Gerd was relieved to get a clean bill of health.

"It poured for eight of the ten weeks I spent in the Lake District," says photographer ANNIE GRIFFITHS BELT. "Listening to the English weather reports on the news was like opening a thesaurus to the word rain: 'Showery bits this evening, later turning to drizzle, followed by downpours and mists.' But I came to love it. The rain is the reason everything there is so green and beautiful."

One such green, beautiful place—on a rare sunny day—was the hilltop Lowther Estates, a private game park where Annie, clad in camouflage, with hunter Kirk Robertson, captured a roving herd of red deer in her viewing scope.

"Deerstalking is a rough, slow business," she says. "You crawl up to a stag on your belly and elbows. You really have to blend into the background and pull your hat low; even a flash of forehead might scare him away."

As a journalism student at the University of Minnesota, Annie started out with dreams of a writing career. "Then, my junior year in college, I got a camera," she says. "I switched my major to photography two weeks later."

In addition to her work for the GEOGRAPHIC, Annie teaches, lectures, and has contributed photographs to dozens of books and magazines.

GREGOR CATTANACH

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West Indian Whistling-duck *Genus:* Dendrocygna **Species:** arborea **Adult size:** Length, 48 – 58 cm **Adult weight:** Approx. 1,000 g **Habitat:** Mangroves, forested swamps and reedbeds in the Bahamas, Greater Antilles, and northern Lesser Antilles **Surviving number:** Estimated at 1,000 – 2,000 Photographed by Michael Gore

WILDLIFE AS CANON SEES IT

West Indian whistling-ducks perch on a branch in a Cayman Island swamp. Toward dusk, shrill whistling notes can be heard overhead as the ducks fly to their feeding haunts, especially to feast on royal palm fruit. Throughout the Caribbean, whistling-ducks have suffered from relentless hunting and wetland drainage, and are now reduced to small isolated populations on a few islands. To save endangered species, it is vital to protect their habitats and understand the role of each species within the earth's ecosystems. As a global corporation committed to social and environmental concerns, we hope to foster a greater awareness of our common obligation to ensure that the earth's life-sustaining ecology survives intact for future generations.

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