The canopy crane cruises the treetops at Washington's Wind River Experimental Forest.

SKY DIVERS

FOR THE FIRST TIME IN THE UNITED STATES, RESEARCHERS ARE GETTING TO THE TOP OF THE FOREST CANOPY—IN A CONSTRUCTION CRANE.

BY MICHAEL McRAE

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FOR HIS ENTIRE ACADEMIC CAREER, Jerry Franklin has had his head in the trees—specifically, in the majestic old-growth conifers of the Pacific Northwest. In the 1960s, if the influential University of Washington forest ecologist wanted to inspect the heights of an ailing noble fir or Sitka spruce, he might have spent the better part of a day rigging ropes and clambering up through branches. Although the view was exhilarating, attaining it was neither simple nor safe—nor very efficient. Thirty-five years later, the job has become as easy as this:

"Can we drop down and move over for a closer look?"

It was a warm, clear morning in southwestern Washington. Franklin and I and two of his protégés, David Shaw and Rand Knight, were gliding through the crown of a stand of 500-year-old fir and hemlock trees in the Wind River Experimental Forest, not far from the Columbia River Gorge. Only minutes earlier, we'd been standing amid the huckleberries and trilliums on the forest floor, bathed in the soft light that filtered down from above. Wearing hard hats and body harnesses, we'd stepped into the gondola of a newly erected construction crane, clipped our lanyards onto the cage's safety railing, and been lifted into space. In the parlance of canopy researchers, we had become arbornauts.

The 285-foot-tall crane, owned by the University of Washington and managed by it and the U.S. Forest Service, is the first such installation in North America and the largest of the world's three canopy cranes. The two others are both in tropical forests: One, with a 138-foot tower, has been operated by the Smithsonian Tropical Research Institute in a wooded Panama City park since 1990; the Austrian Science Foundation recently erected the other, a 134-foot-tall crane in Venezuela, on a tributary of the Orinoco River.

Designed for use in congested cities, the behemoths are surprisingly well suited to the close confines of a forest. They're reasonably unobtrusive, have a small footprint, and, most important, permit researchers to get to places that are impossible or too risky to reach by climbing: the tops of trees and the tips of branches, where most of the biological action in a forest—the budding, branching, and photosynthesis—takes place. The disadvantages, of course, are that installing a crane costs in the high six figures; it costs researchers $185 an hour to use; and on top of that, it is stuck in one place—although the one in Panama may be installed on a track in its next proposed location, in a forest at the other end of the Canal.

The upper story of tropical and temperate forests remains one of the least explored realms on earth. Broadly stated, the mission of the Washington project—which is expected to continue for at least five years—is to investigate the structure and function of an old-growth-forest canopy. The project is as much about basic science as about applied forestry. One objective, for instance, is to understand how a natural forest operates, in order to design second-growth stands that mimic old-growth ones. This is the mandate of the "new forestry," of which Franklin is a chief architect. The strategy is to retain some "legacy trees," snags, and deadfall when logging so that managed forests will have as much structural complexity—which translates into genetic and biological diversity and wildlife habitat—as possible.

RICH FRISHMAN FOR *AUDUBON*

Operating from the crane's gondola, researchers can return repeatedly to their study sites to monitor the forest's physiology.

The initial work at the site will concentrate on gathering baseline data about the 1,200-acre study area, officially designated the Thornton T. Munger Research Natural Area, after a pioneering silviculturist who worked in the Wind River valley. "We're sailing into new waters, so the first thing you do is describe the coarse terrain," explains Smithsonian forest ecologist Geoffrey Parker, a veteran of the Panama crane who studies the relationship between structure and process in the canopy. Unlike the dense, rooflike outer surfaces of tropical hardwood forests, coniferous forests in the Pacific Northwest have a complex landscape of spikes, gaps, and canyons. The greater a forest's "rumple factor," as Parker terms it, the greater its capacity to harvest gases, moisture, and particulates from the atmosphere, he believes. As a first step in his investigations, he is making a topographic map of the canopy with the help of a digital laser range finder. The database of measurements will eventually be so sophisticated that Parker foresees a computer-animated simulation of the upper canopy as a bird might experience it.

A team from the University of Washington's remote-sensing laboratory had the crane after us. They arrived with a battery of imaging equipment to analyze the spectrum of light being reflected by the canopy, since reflected light is one "signature" that can reveal much about a forest, from its age to its timber productivity. The aim of their study, funded by the National Aeronautics and Space Administration, is to permit scientists and resource managers to better interpret satellite images of the region's late-successional forests. "Right now, it's difficult to tell by remote sensing the difference between a 250-year-old forest and a 500-year-old one," says project coordinator Jan Zukin, a University of Washington geophysicist who has used sonar to map undersea ridges off Easter Island. "Eventually, we want to help ecologists who come to us and say, 'I need a map of such-and-such old-growth forest, because a particular species of animal lives there.'"

Later studies will begin to fill in blanks about the intricate web of life in the canopy. With the crane in place, biologists who have never climbed a tree in their lives can look at microscopic organisms on the surface of needles—the yeasts, algae, and bacteria that Franklin calls scuz—to determine their role in the food chain. Others are eager to examine fungi that live in the needles and seem to offer protection from herbivores. Physiologists will measure the photosynthetic-energy contribution of needles at various levels, relating that to the amount of light falling on the needles.

Franklin himself is intrigued by the life cycle of insects that live in the soil and along streams but may mate in the canopy. Biologists want to know where bats roost. Shaw, the site director and an ecologist specializing in tree diseases, has started examining dwarf mistletoe, a potentially devastating parasite that infects huge numbers of western hemlocks.

The crane will operate both day and night, all year long. In winter, for instance, researchers will study how much rain and snow an old-growth canopy intercepts and holds, and how snow retention may reduce the kind of storm runoff and erosion that characterizes second-growth stands.

Recently there has been talk of arboreal science's entering a golden age. As late as the 1930s, researchers were training domesticated monkeys to fetch samples from the canopy of Malaysian jungles. Botanists have put slingshots, pole pruners, and insect foggers to similar use. They've borrowed techniques and hardware from alpinists, cavers, and arborists. They've fired ropes from crossbows, ascended via boatswain's chairs, lineman's spikes, ladders, even the ankle straps that Amazonian natives use to worm their way up tree trunks.

Advances in climbing equipment, including such innovations as cranes and a dirigible that has been deployed in French Guiana and Cameroon, have propelled canopy studies beyond the purely observational and taxonomic—surveying and cataloguing work—to experimental research. Operating from a safe, stable platform like the Wind River gondola, researchers can return repeatedly to their study sites to monitor the physiology of a forest, to see how it interacts with the atmosphere, how nutrients cycle through the ecosystem, what role lichens and other epiphytes play.

"Canopy research is in its infancy," explains Franklin. As the prime mover behind the Wind River crane, he secured from Congress a $1 million appropriation, fended off opposition, and now serves as program director. "There hasn't been a whole lot of meat-and-potatoes work yet. . . . We're

UPPER CANOPY (A)

Trees:	Western hemlock, Douglas fir
Epiphytes:	Old-man's beard, tube lichen
Birds:	Hermit warbler, Vaux's swift, evening grosbeak, red crossbill
Mammals:	Northern flying squirrel, Douglas squirrel

MIDDLE CANOPY (B)

Trees:	Western red cedar, grand fir
Epiphytes:	Old-man's beard, cyanolichen
Birds:	Brown creeper, red-breasted nuthatch, chestnut-backed chickadee, Hammond's flycatcher, golden-crowned kinglet

LOWER CANOPY (C)

Trees:	Pacific silver fir, Pacific yew, Pacific dogwood
Epiphytes:	Moss (Dicranum tauricum and fuscescens)
Birds:	American robin, brown creeper, winter wren
Mammals:	Marten, weasel

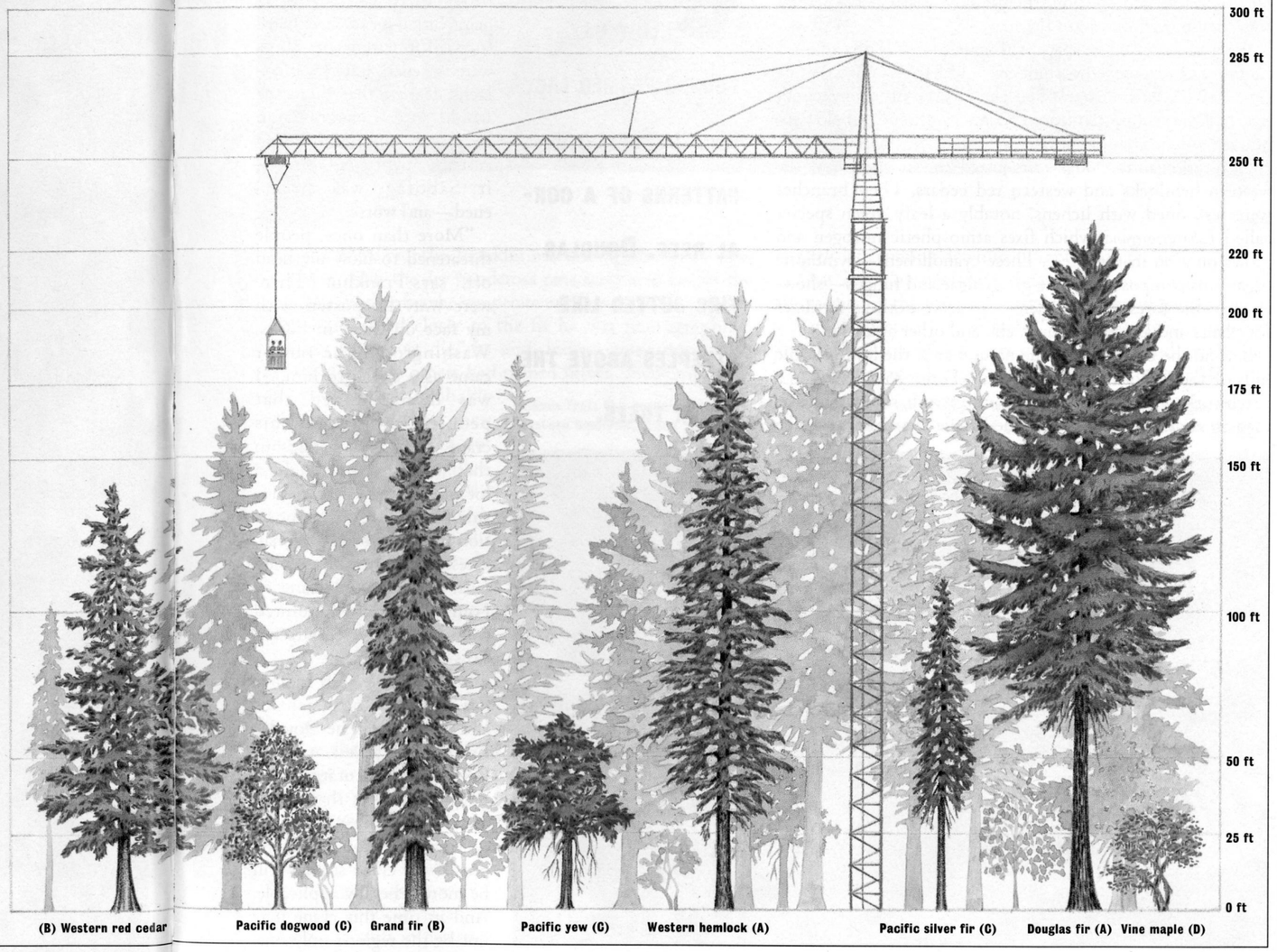
UNDERSTORY (D)

Shrubs:	Vine maple, salal, dwarf Oregon grape
Subshrubs:	Vanilla leaf, inside-out flower
Epiphytes:	Moss (Dicranum tauricum and fuscescens)
Birds:	Swainson's thrush, rufous-sided towhee, hermit thrush, dark-eyed junco
Mammals:	Black bear, elk, bobcat, black-tailed deer, coyote, mountain lion, deer mouse, Townsend's chipmunk, shrew mole

CAVITY

Mammals:	Big brown bat, long-legged myotis, silver-haired bat, weasel, marten, northern flying squirrel

—Research by Amanda Onion and Joanna Samuels



RICH FRISHMAN FOR *AUDUBON*; ILLUSTRATION BY SUZANNE BARNES

just getting to the point where we can do some real research, and that's what this crane is all about."

The crane, in short, is the long-envisioned "skyhook" that can whisk a team and monitoring equipment into the treetops, giving them tremendous mobility. Once airborne, researchers can travel anywhere within a cylinder of space whose base could accommodate two football fields laid end to end. With a reach of 279 feet, the crane's horizontal boom, or jib, swings through an arc encompassing 5.6 acres.

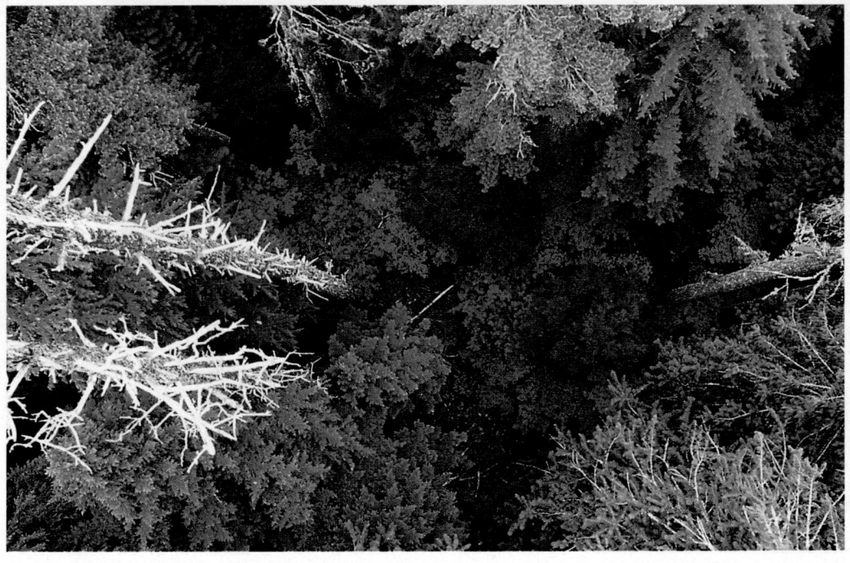
Rising into the sunny canopy or descending into the shade of the forest floor evokes sensations I've felt diving on coral reefs: the shifts in light, the three-dimensional mobility, the sense of buoyancy, of floating. One moment we could be skimming the top of the tallest tree, the next stepping off the gondola to examine the smallest seedling.

After about 30 minutes aloft, something caught Franklin's eye in the crown of a grand fir, and he wanted a closer look. Shaw radioed Franklin's request to the crane operator. Silently, as if by levitation, the gondola eased down several feet, then moved in toward the fir.

We were hovering in space within arm's reach of the tree's summit, a perspective no climber could have attained. While Franklin busily photographed the cluster of resiny cones that had drawn his attention, I let my eyes wander. Below us, boughs formed lacy whorls resembling the patterns of a coral reef. Gigantic Douglas firs jutted like steeples above the western hemlocks and western red cedars. Their branches were festooned with lichens, notably a leafy green species called *Lobaria oregana,* which fixes atmospheric nitrogen and grows only on mature trees. These cyanolichens—symbiotic organisms composed of blue-green algae and fungus—shower onto the forest floor, where they serve both as fertilizer for plants and as food for deer, elk, and other animals.

Beyond the boundary of the natural area, the low, volcanic hills of the Gifford Pinchot National Forest rolled away in a patchwork of clearcuts and second-growth stands. This is logging country, but it is also the Pacific Northwest's cradle

BELOW US, BOUGHS FORMED LACY WHORLS, LIKE THE PATTERNS OF A CORAL REEF. DOUGLAS FIRS JUTTED LIKE STEEPLES ABOVE THE OTHER TREES.

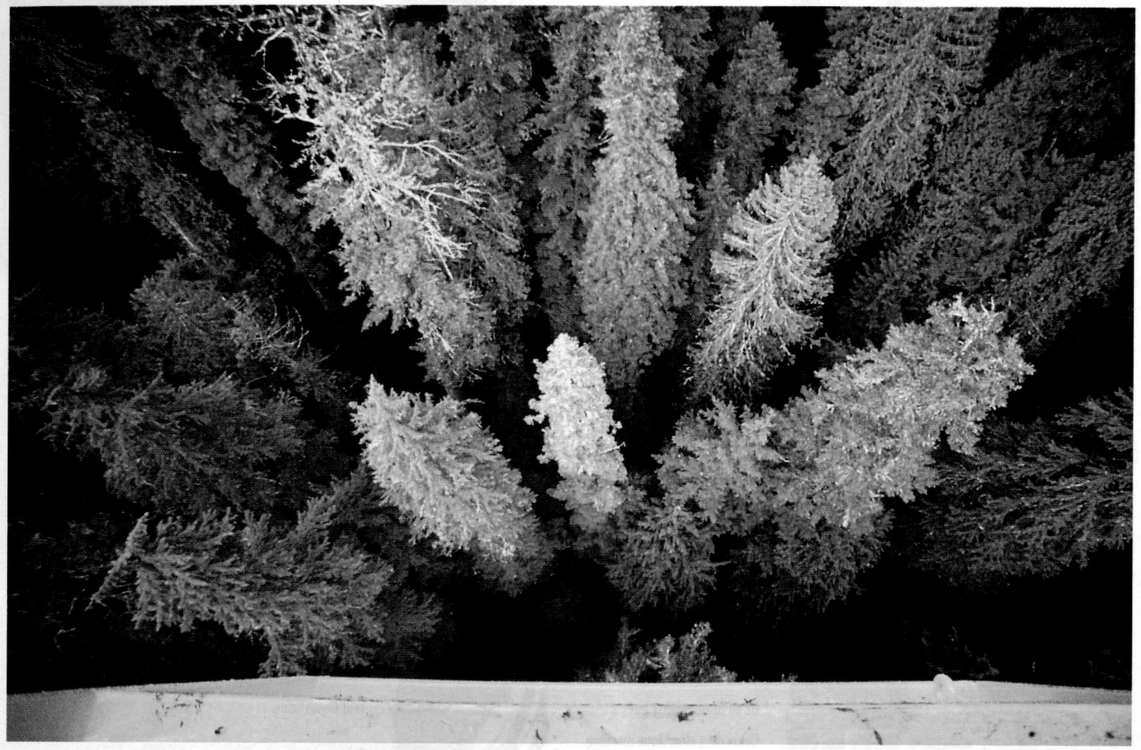


of forest research. The Wind River tree nursery dates to 1909, and an arboretum with 125 species of native and exotic conifers was started in 1912. Over the years, more than 250 tree species have been tested here, but none have done as well as the native Douglas fir, one of the area's most important commercial species.

That the crane ended up in a fir forest with such a research tradition was not by design. The first choice was a site on the western Olympic Peninsula, in an old-growth rainforest of giant Sitka spruce and hemlock. But when the plans were unveiled, irate local citizens, fearing that the crane would supply ammunition to justify further logging cutbacks, petitioned to block it. Sabotage was threatened—and worse.

"More than once, people threatened to blow my head off," says Franklin. "There were WANTED posters with my face on them in Forks, Washington." The rancor came as a shock to him. "I was dumbfounded that people did not want this crane. I saw it as a flagship that would have brought a lot of science to the peninsula." Some of the opposition may have been personal, a result of Franklin's tenure with the so-called Gang of Four, a federally appointed team that suggested alternatives to clear-cutting.

Ironically, the shift in sites has benefited both science and commerce. The Douglas fir–hemlock forest at Wind River is representative of a much larger area than is the coastal rainforest, so management techniques growing out of the crane studies will be more generally applicable. And in time this crane may not be the region's only one.



CLOCKWISE FROM TOP LEFT: RICH FRISHMAN FOR *AUDUBON*; MARY LEVIN/UNIVERSITY OF WASHINGTON; JERRY F. FRANKLIN (TWO)

After just three months, Franklin was musing about two others: one to study the dry ponderosa pine ecosystem east of the Cascades, another for the temperate rainforests on the coast.

Franklin leaned closer to the fir he was photographing. "See, the cones just die," he said. Indeed, some were green and healthy, while others had turned brown. Shaw explained that a moth had probably laid her eggs in the cones; the larvae that hatched out had devoured the insides. But that was only part of the food web. Jays and woodpeckers would feed on the larvae; parasitic wasps would lay eggs on them.

Just then, a wasp no bigger than a straight pin appeared, flitting from cone to cone, prospecting for a larva to host its eggs. A hush fell over us as we watched, our noses inches from the insect—175 feet up in space.

The wasp flitted away. Our allotted half hour had stretched to 45 minutes. "Okay," said Franklin. "Time to go back to work." When the gondola began its descent, the shift in perspective felt like coming down from rapture of the deep.

That consciousness-expanding quality may be the key to the secrets of the forest. "Most of what we've gained here is a new perspective," Shaw said. "The crane changes the way you think. After fifteen years of running around on the forest floor, my mind's eye is now in the upper canopy."

Scenes from the gondola (top left): A bird's-eye view of the canopy at Wind River (bottom left); Douglas fir, western hemlock, grand fir, and western red cedar (above); close-up of grand fir in the middle canopy (below).