JOHN EASTCOTT AND YVA MOMATIUK

age. Still, the long walks allow the species to prosper even as the birds ravage more habitat. And female young will return to the new locations to raise their own young.

Long lives: If snow geese were shorter-lived birds, the loss of goslings to the habitat destruction of breeding grounds would reverse the population explosion. But snows commonly live and breed into their teens, and a few hardy females may continue to live and nest past the age of 20. Life expectancy of adults has actually increased since the 1950s. If they raise two young to adulthood, they've replaced themselves. Any more, and the population continues to grow even if large numbers of young die.

Search for solutions: U.S. and Canadian waterfowl experts are calling for an all-out effort to reduce the population of mid-continent snow geese to a level that can be sustained by their arctic and subarctic habitats. Waterfowlers may be allowed to use hunting techniques that have been banned in the past because they are so effective, such as electronic calls or baiting. "There's a finite amount of good habitat, and we're running out of it," says Bruce Batt, chief waterfowl biologist with the nonprofit group Ducks Unlimited. "Now is the time to intervene." ❑

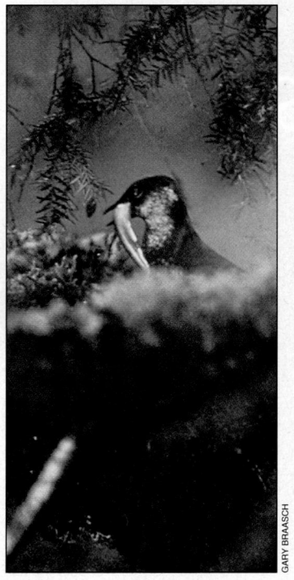
Lisa Drew is a senior editor of this magazine. Chris Madson writes from Cheyenne, Wyoming, where he is editor of Wyoming Wildlife *magazine.*

LOOKING AT OLD GROWTH *FROM NEW ANGLES*

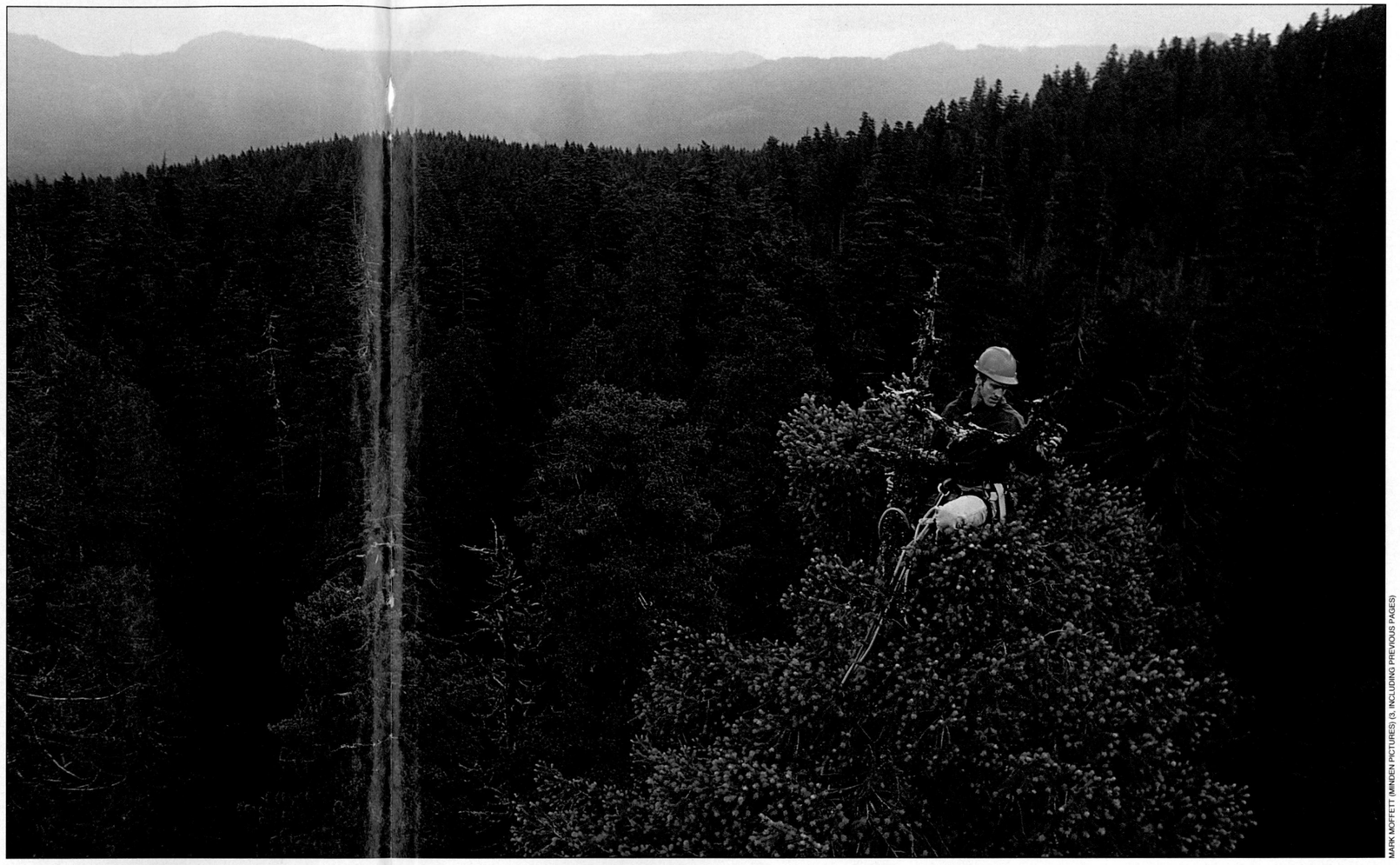
From treetops to roots, aging woods still hold plenty of surprises for researchers

DANGLING from the Wind River Canopy Crane in a gondola piloted from above, biologist and crane director David Shaw surveys a new frontier: the canopy of old-growth forest. Crane operator Mark Creighton uses computer coordinates to move the gondola to specific locations among six acres of a research area in Washington's Cascades. Study subjects here range from climate change to bat behavior.

By Kathie Durbin



GARY BRASCH



MARK MOFFETT (MINDEN PICTURES) (3, INCLUDING PREVIOUS PAGES)

WHEN the silver-spotted tiger moth caterpillar (top) dines on treetop needles, more light reaches the forest floor. To study such phenomena, scientists often must travel the hard way, like this researcher (right) examining lichens in a Douglas fir. Such work signals a new era in forest science, which is also considering life below the canopy, like this endangered marbled murrelet (above) feeding fish to young in a western hemlock.

ON A DRIZZLY MORNING last April, scientists Jim Lewis, Bob McKane and Peter Beedlow head for a laboratory unlike any other in North America. They walk through a forest of 500-year-old conifers to a giant construction crane. They don harnesses fitted with carabiners, haul sophisticated electronic gear aboard the crane's gondola and attach themselves to rings on the gondola's inner walls.

Traveling from forest floor to forest ceiling is a smooth, fast trip—an elevation gain of 220 feet in two minutes. The researchers can see nearby Cascade peaks, clear-cuts, tree plantations and the Wind River flowing through a corridor of budding alders. From up here, it's easy to see where old growth ends and the bright, even-topped younger forest begins. Old-man's beard, a pale-yellow epiphyte, hangs from venerable Douglas firs, hemlocks and cedars. Broken crowns of live trees punctuate the green canopy with splashes of orange heartwood. Stark gray fingers of dead snags point skyward. Silviculturists call the canopy's exposed branches "sun foliage" because they get more light, wind and extremes of temperature. That affects how they grow—their "bunchiness."

Swaying gently, the open-air elevator rises past the tips of old-growth Douglas firs and enters a world of sky and clouds. It is silent up here where most of the forest's essential processes occur—where the sun's energy is captured and the cycling of water from soil to atmosphere is regulated.

Below is a rolling, uneven forestscape of widely spaced conifers, with clear views of melting snowbanks on the ground. "What strikes me is how uncanopylike the canopy is," says Beedlow, a U.S. Environmental Protection Agency (EPA) ecologist. "When you walk around on the forest floor, you don't get the same sense of its roughness." Scientists have even invented a word—"gappiness"—to describe the uneven treetop topography.

Changing attitudes: Such observations are signs of a new era in forest science, which today is teaching us how much more there is to a tree than sawtimber, how much more there is to a forest than trees. As recently as the 1970s, research in the Northwest's forests was preoccupied with finding efficient ways to cut down old trees and replace them with young plantations. Now, managers are understanding that a century of overcutting, fire suppression and livestock grazing has left many forests in deteriorating condition and many wildlife species in decline.

As part of that growing awareness, the Clinton administration is pushing to implement ecosystem management in the Pacific Northwest, the Interior Columbia Basin, California's Sierra Nevada and Alaska's Tongass National Forest. "Increasingly, we are studying large-scale integrated issues about the management of land—issues that have not only a biological but a socioeconomic component," says Thomas J. Mills, director of the U.S. Forest Service's Pacific Northwest Research Station.

Such approaches may have their pitfalls. Resource specialist Rick Brown of the National Wildlife Federation worries that some specific wildlife species may fall through the cracks. "Ecosystem-level approaches are essential, but when you have a landscape that has been hammered, and so many species are at risk, you have to look at their individual needs," he says. Still, forest science overall is moving far beyond its old goals, and it is yielding a treasure trove of findings, some of which may have direct implications for forest management.

Because ecosystem management asks land managers to design timber sales that emulate nature, researchers are taking a closer look at natural disturbances such as floods and fires. For instance, fish biologists, hydrologists and geologists collaborated on recent studies of Pacific Northwest floods. In one case, Forest Service researchers Fred Swanson and Gordon Grant compared the effects on one forest of two floods, in 1964 and 1996. They found that although the 1964 flood was less severe, it triggered more landslides, reshaped more river channels and dumped more silt into streambeds.

Today's forest science is teaching us how much more there is to a tree than sawtimber, as well as how much more there is to a forest than trees.

The reason may be related to a halt in logging at the study site. Just prior to the 1964 flood, the site had experienced 15 years of logging and road construction. "But leading up to 1996," says Swanson, "we'd had virtually no road construction and no logging."

A 1995 study of the fire history of three Oregon coastal watersheds by Forest Service fish biologist Gordon Reeves and colleagues found that before aggressive fire

suppression began, wildfires in the region typically altered forest composition across entire watersheds. In contrast, fire is virtually unknown in the wet Alaska rain forest, where the main sources of natural disturbance are landslides and windstorms that topple small stands of trees.

One conclusion to be drawn, according to Mills, is that maybe logging in the Northwest should take place intensively, one watershed at a time. In Alaska, conversely, researchers are now studying the ecological effects of logging that creates smaller openings in the forest.

Recent research by Joy Belsky, staff ecologist for the Oregon Natural Desert Association, a conservation group, fingers another culprit in the decline of interior forest: livestock grazing. Belsky's peer-reviewed study, published in the journal *Conservation Biology*, argues that livestock played a larger role than fire suppression in creating today's dense forest. Her study of historical records documents that long before Smokey Bear, ground fires that maintained open spaces in ponderosa pine and larch forests became less frequent. The reasons: Cattle and sheep ate the native grasses, and conifer seedlings filled in the spaces between large, fire-resistant trees.

Mushrooming demands: New pressures on the forest also create new demands for research. In recent years, Northwest forests have seen an explosion in the harvest of what the Forest Service calls "special forest product"—ferns, mosses and lichens for floral arrangements; and wild mushrooms for export to Japan. In recent years, mushroom hunters have harvested millions of pounds of chanterelles, morels and matsutakes.

A study by Forest Service botanist Randy Molina indicates that careful harvest of mushrooms is not harmful to the host tree. But when harvesters use rakes to uncover mushrooms in the forest duff, they can break the filaments that connect the fungus to the roots of its host tree—the mycorrhizae. That could disrupt the exchange of carbon and nutrients between tree and fungus, impairing future production of the fungal "fruit."

The new mushroom research has some surprising implications for forest management. For instance, some lodgepole pine forests are prolific producers of matsutakes, which can bring as much as $100 a pound in Japan. "We believe that the sustainable harvest of matsutake mushrooms over time may have greater value than the one-time harvest of lodgepole," says Molina. Morel mushrooms thrive in forests where large numbers of trees have been killed by insects or fire.

Some entrepreneurs have discovered treasure in the mosses, lichens and salal that grow in wet coastal forests. In 1995, an estimated $14 million worth of mosses and lichens were exported. No one knows the value of the domestic trade. Research on the environmental consequences of the harvest is in the early stages. But already Forest Service plant physiologist Nan Vance has discovered that at least 35 species of mosses, lichens and liverworts grow on old vine maples. "The older the maple, the more kinds of mosses," she says.

MARK MOFFETT (MINDEN PICTURES) (2)

GIANT SEQUOIA CONES (above) offer habitat for lichens, which have a hard time growing elsewhere on their host because of sloughing bark and toxins in the tree. The cones grow for as long as 20 years, gradually accumulating lichens, which means that lichen growth can indicate cone age. For indications of insect diversity in Sitka spruce treetops (left), a ladder, ropes and nets have helped intrepid researchers collect hundreds of new anthropod species.

Looking up: Until three years ago, the Northwest's forest canopy was a largely unexplored frontier. Intrepid researchers had to climb trees or stand on makeshift platforms or scaffolds. Then, in 1995, the U.S. Forest Service's Pacific Northwest Research Station and the University of Washington College of Forest Resources inaugurated the 250-foot Wind River Canopy Crane at an old-growth research area in Washington's southern Cascades. The crane, one of only four in the world used for such research, allows scientists to move easily within wide circles in nearly six acres of canopy.

It takes a lot of energy and about 36 hours for a tree to lift water and nutrients from its roots 200 feet to its upper branches. Questions of how water, photosynthetic energy and nutrients travel within these large old trees have brought Beedlow of the EPA together with Lewis and McKane, both staff ecologists for the National Research Council, on an EPA project. Their work measuring photosynthesis under varied environmental conditions will establish baseline information that may help predict the effects of global climate change.

When the gondola reaches the top

TOM MANGELSEN

AWARENESS of the dependence of the northern spotted owl (left) and other wildlife on old growth has helped foster new approaches to forest management and research. Managers also are increasingly taking into account the value of forest products other than wood, such as edible "chicken of the woods" shelf fungus (below left); highly valued mushrooms such as morels and matsutakes; and a variety of ferns, mosses and lichens.

branches of a specific hemlock, the scientists set to work. Lewis leans out, grabs a branch and inserts it in a clear tube. The tube is attached to a machine that measures temperature, barometric pressure and levels of water and carbon dioxide. By comparing readings inside and outside the tube, Lewis can determine the needles' rate of photosynthesis and ability to conduct water. Beedlow hoists a 3-foot-long light box attached to equipment that allows him to correlate rates of photosynthesis with available light in the canopy.

McKane's task is to place individual needles in a pressure chamber that helps researchers correlate rates of photosynthesis with the amount of water in the branch. With samples taken for study in the laboratory, researchers will also study the rate at which the tree takes up, processes and evaporates water and nutrients. Like many species of wildlife, trees store food. Half of their carbohydrate production occurs in the late fall, winter and early spring, and new growth in the late spring and summer draws on these stored carbohydrates.

GARY BRAASCH

Not all the work at the canopy crane is this technical. Biologist and crane director David Shaw conducts weekly counts of neotropical songbirds at dawn to learn more about which birds make use of which canopy levels. Insectivores such as winter wrens tend to occupy the lower canopy, he has learned, while seed-eaters such as the red crossbill keep to the uppermost branches, where cones are plentiful. Northern pygmy owls and barred owls occasionally pass through, and northern goshawks show up and stay to dine when Douglas squirrels are abundant.

The crane has also helped the Forest Service experiment with environmentally benign methods for controlling the bark beetles that have defoliated large swaths of interior Northwest forest. Bark beetles use chemicals, or pheromones, to communicate. The pheromone that announces "dispersal time" has been synthesized and is widely used to protect log decks from the beetles.

The unanswered question is: How much of this chemical is enough to control insects in a stand of trees? That requires understanding how wind moves through the canopy. With the help of the crane, Forest Service researcher Warren Webb is using smoke bombs and smoke machines—the kind used by rock stars in music videos—to determine air current. While he and his associates pump out the smoke, observers with video cameras on the ground and at various levels in the trees record the movement of the colored smoke.

In other work, John Hayes, a wildlife ecologist at Oregon State University, is listening to bat echolocation, a kind of sonar. Bat detectors pick up the high-frequency signals bats emit to navigate and communicate and convert them to frequencies the human ear can detect. The crane has allowed Hayes to install the machines on suspended platforms at various levels in the forest. They're hooked up to voice-activated tape recorders that also record the time, saving him the need to spend long nights in the canopy. So far, he has collected close to a dozen nights' worth of data and has learned that bats "like warm nights with lots of insects."

"The crane allows us to study bats that are active high in the forest's canopy," says Hayes. Already, he has documented clear differences in amounts and timing of bat activity at different levels in the forest—and he has found that certain bat species are partial to certain forest levels.

If there's a lesson to be drawn from the dizzying variety of research projects now underway in Northwest forests, perhaps it is this: From the invisible, life-enabling exchanges that take place in the forest canopy to the mysterious realms of mushrooms and mosses, forests work in ways we have only begun to comprehend.

As the canopy crane descends, the forest floor seems to rise to meet it. On solid ground again, the scientists are surrounded by the damp musk of the Douglas firs, the perfume of the cedars. The crane has bridged the distance between the known world and another that until recently was as unfamiliar as the surface of Mars. Who knows what else the forest might teach us, if only we will listen? ❑

Oregon writer Kathie Durbin, author of Tree Huggers: Victory, Defeat and Renewal in the Northwest Ancient Forest Campaign *(The Mountaineers, 1996), accompanied scientists on the Wind River Canopy Crane.*

Forest Conservation
An NWF Priority

The National Wildlife Federation applies the results of forest research to conservation efforts that span the continent, from protection of the forests of northern New England to habitat conservation planning in the state forests of western Oregon. Some of the most pressing issues involve proposed plans for public lands in the Columbia Basin of the inland Northwest. To find out how you can help, contact NWF's Western Natural Resource Center, 2031 SE Belmont St., Portland, Oregon 97214, or visit our website at www.nwf.org.