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A Community of Equals

by M. L. Herring

It's raining. Wind stirs the tops of tall trees, but the sound seems far away. A dome of overlapping branches buffers the wind, absorbs the rain. Down on the forest floor, the air is saturated and still. Opulently, plants drape over other plants in a profusion of life. A huckleberry bush sprouts from the broken top of a giant old hemlock. Hanks of lichen like long, green hair hang from the branches overhead. Green cushions of moss erupting with ferns cover a tumble of logs. Against the Gothic backdrop of five-hundred-year-old trees, 30 people stand in the soaking mist. Graduate students from the University of Washington have come to the H. J. Andrews Experimental Forest in Oregon's Cascade Mountains for a close look at an old-growth ecosystem. At the moment, the political storm that is raging over the fate of the nation's forests seems as distant as the wind above us. The man who has helped to stir the storm, Jerry Franklin, introduces his class to the old-growth forest as if to an old friend. Franklin, author of the first comprehensive ecological study of the Pacific forest (published, incredibly, not until 1981), has played, studied, and worked in the forests of the Pacific since he was a boy, and he probably knows them as well as anyone alive.

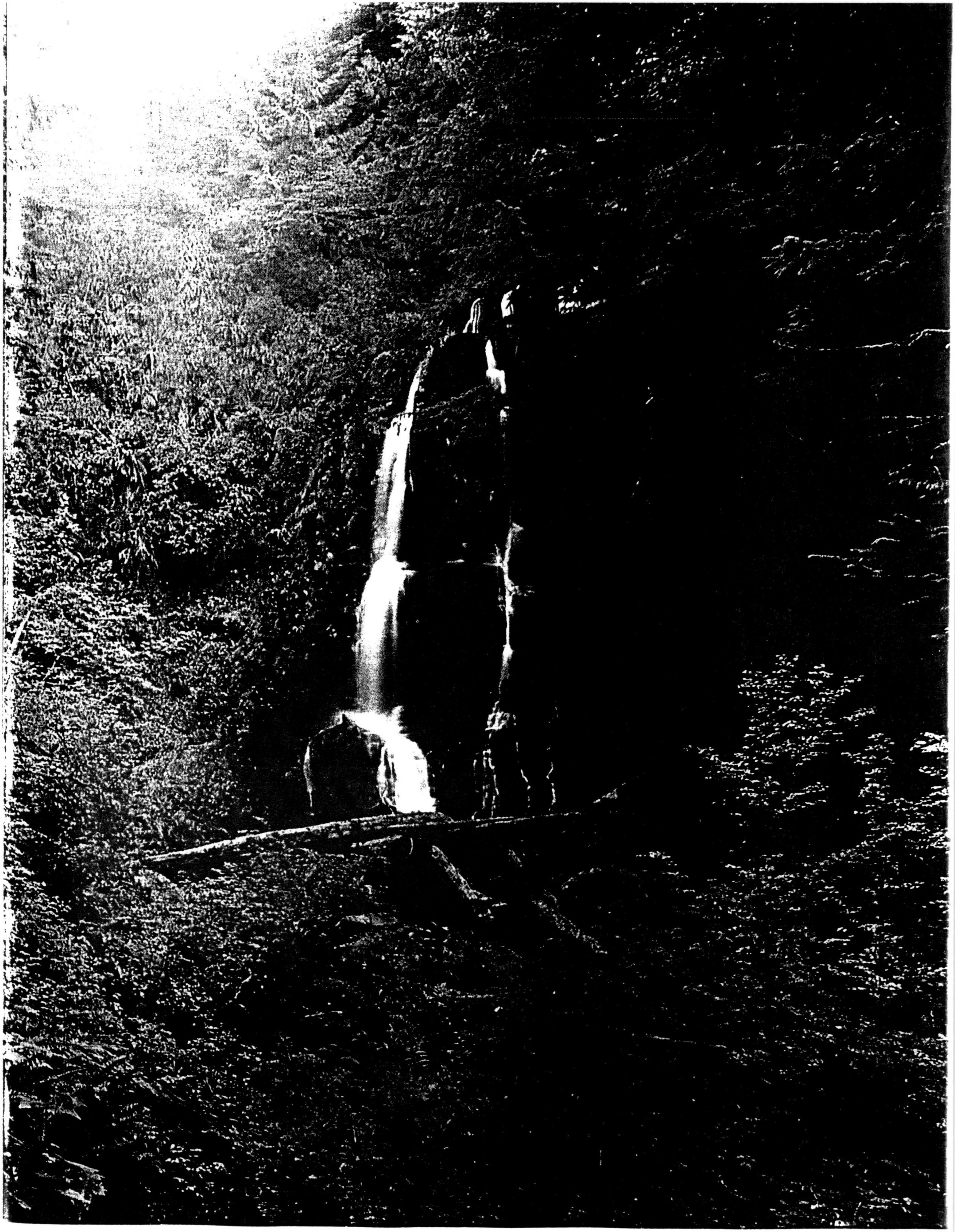
"When you sit there for four or five hundred years you tend to become very distinctive, very individual in your characteristics," Franklin says. "You develop crooks and crannies and rotted out places. Your branches stairstep deeply into the canopy. And you provide for a tremendous amount of species diversity."

The Andrews Experimental Forest, known as simply *the* Andrews, is the site of many of the first studies done on old-growth temperate rainforests. It was started in 1946 when the old paradigms of forestry were well entrenched.

The ancient, uncut forest was considered then to be nothing more than an assemblage of overripe trees slowly wast-

Water brings lushness and life to the forests of the Pacific Northwest, which contain some of the world's oldest and largest trees. Landscapes like this one in the Siuslaw National Forest in Oregon contain myriad plants, animals, and other organisms that depend on the ancient sodden and rotting trees in intricate ways.

GEORGE OSTERTAG



ing away—a biological desert compared with the young regenerating forest growing back on cutover land. Douglas fir was found to regenerate quickly on open, burned ground. The first work at the Andrews was to figure out a way to clearcut the old trees and replace them with fast-growing plantations.

During the 1970s, the Andrews was included in an international ecosystem research program, and the old-growth forest that up to then had been the object of liquidation suddenly became the subject of a new generation of research.

Franklin, now chief plant ecologist for the U.S. Forest Service, spearheaded this landmark research. "Here were these magnificent forests," he recalls, "and we didn't know anything about them except how to cut them down."

The ecosystem research at the Andrews has brought together an interdisciplinary group of scientists from ten different departments at Oregon State University, the Forest Service, and the University of Washington to describe how the entire forest ecosystem interrelates. It is a unique laboratory where research can be integrated into the management of the surrounding National Forest.

"One of the important things that has come out of the Andrews group," explains Franklin, "is an appreciation for the richness and complexity of the natural forest. It's true to an extent of all types of natural forest, but the old-growth represents processes and concepts at their maximal representations, extreme representations of age, massiveness, structural diversity, and coarse woody debris. If you had to summarize the characteristics of the old-growth forests it would have to be in terms of their complex structure, the key not only to their habitat diversity and the large numbers of organisms they support, but also to their variety of processes and functions. This is the perfect antithesis of what we've tried to create through management, which is a simple, uniform stand of trees of a single species and a single age."

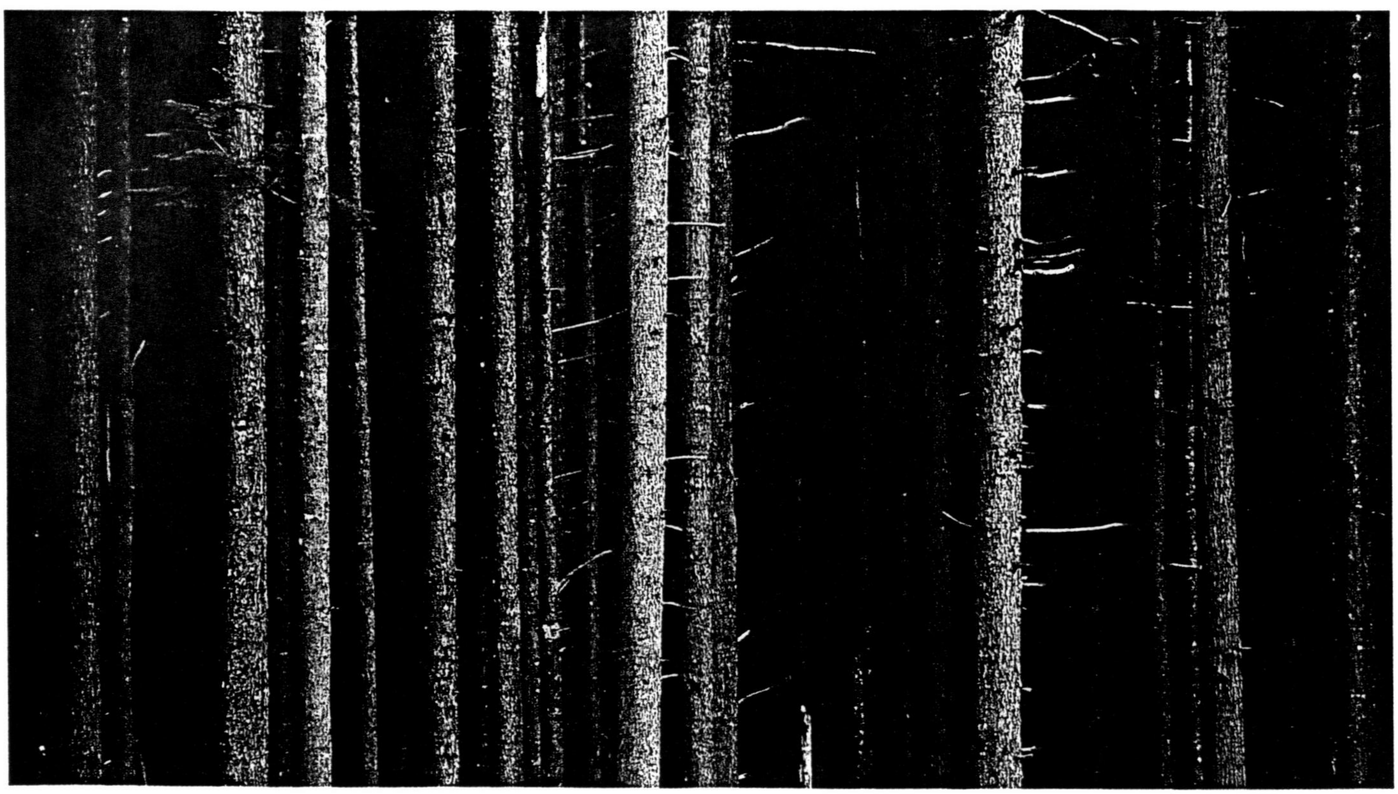
THE FORESTS of the Pacific Northwest represent the most extensive temperate forests left in the world. They contain some of the oldest and the largest trees on Earth. Some ecologists maintain that they may hold more living mass than even the fabled tropics. These forests are productive for an exceptionally long time, accumulate huge supplies of downed wood, and store the most carbon of any terrestrial ecosystem.

"I like to think that this is what a forest can be," Franklin laughs as he gestures towards the magnificent heights. "What other forests can aspire to." In truth, few forests in the Pacific Northwest have been managed with these aspirations in mind.

The history of the region follows a direct course of deforestation. City Halls in logging towns from the redwoods to the Olympic Mountains display sepia-toned prints of solemn pioneers hacking away at the bases of gigantic old trees. The photos do not show the rapacious waste of those giant trees that led to an act of Congress in 1891, which gave the President authority to protect forest reserves. The act survived long enough for over a hundred million acres to be protected in what would become the first National Forests.

In the Northwest, most federal forests were located on high, steep land where private timber companies had found it too much trouble to log. Therefore, the National Forests remained relatively uncut until after World War II, when the privately-owned, low-elevation timberlands were all but exhausted, and a post-war

These young western hemlock trees, with their uniform gray trunks, grow in a plantation on the west side of the Olympic Peninsula. Such second-growth stands have replaced most of the diverse old-growth forest.



DAVID MIDDLETON

nation hungry for new housing turned to the federal forests for timber.

Escalating harvests over the last 40 years have splintered the National Forests and threatened the wildlife that live there. Unfortunately, wilderness areas, often made up of upland forests, sometimes characterized as landscapes of rock and ice, do not make hospitable sanctuaries for threatened species from lower elevations.

Now, one hundred years after designation of the first forest reserves, the public again decries the plunder of the nation's natural resources. The priorities of forestry are shifting from timber production to species protection, and at the center of the storm is perched the northern spotted owl *(Strix occidentalis)*.

Elfin, almost childlike in appearance, the northern spotted owl is an unlikely symbol around which to stage a revolution. Very little was known about the bird until a few years ago when researchers working at the Andrews recognized its affinity with old-growth forests. Last year the U.S. Fish and Wildlife Service listed the owl as a threatened species, and later, pressured by the lawsuit, *Northern Spotted Owl v. Lujan*, recommended logging restrictions on 11.6 million acres of newly created Habitat Conservation Areas (HCAs).

But many other species also stand at the cutting edge of survival as their old-growth habitats disappear. Many cavity-nesting birds need old-growth forests. Pileated woodpeckers *(Dryocopus pileatus)*, for example, depend on large snags as a source of insects as well as a place to nest. Biologists working in the Willamette National Forest expect their population of pileated woodpeckers to crash to 20 percent of present levels in the next 40 years as suitable snags fall and are not replaced.

Many distinctive mammals are resident in the old-growth forest. The diminutive red tree vole *(Phenacomys longicaudus)* lives high in the canopy of mature Douglas fir trees, where it feeds almost exclusively on needles. Scientists believe that generations of red tree voles may live, breed, and die in the same tree.

In contrast, the red-backed vole *(Clethrionomys californicus)* lives in underground burrows beneath well-rotted logs and feeds primarily on truffles, the fruiting body of underground fungi. Truffles are a staple for northern flying squirrels *(Glaucomys sabrinus)* as well. Researchers from the Andrews explain how red-backed voles and flying squirrels help disperse the fungi that are so important to growing healthy conifers. Many of these fungi form specialized extensions on the roots of trees that help to absorb nutrients and water from the soil. The trees in turn provide carbohydrates to these mycorrhizal fungi and shelter to the voles, squirrels, and owls in an interlocking weave of forest life.

ANOTHER SPECIES woven into the old-growth forest is the marbled murrelet *(Brachyramphus marmoratus)*. "Enigma of the Pacific," ornithologist C. J. Guiguet dubbed the marbled murrelet in 1956. The birds, he wrote, "move about at night to and from their terrestrial nesting grounds, and their daylight hours are spent at sea. During the breeding season they become agitated as daylight fails, anxious it seems, to relieve the incubating mate, or to feed the young one as the case may be."

And enigmatic they were. Ornithologists since early in the century had observed the marbled murrelet's dusk-to-dawn commutes, but it was not until 1974 that the first nest was found in a North American forest. Ground nests had been discovered much earlier in the treeless tundra, but along the Northwest coast, marbled murrelets were found to nest only in trees . . . big, old trees.

The first nest was discovered in Big Basin Redwoods State Park in the Santa Cruz Mountains. Up 150 feet into an old Douglas fir six miles from the coast, a climber found a chick nestled in a bed of moss. Since then, 15 more active nests have been discovered in California, Oregon, and Washington, all in the large, horizontal limbs of older conifers.

"These little guys are not easy to track," says Paul Englemeyer, a tree climber hired to investigate potential nest sites. "We hear them sometimes in the early morning as they whiz up the creek about 60 miles an hour, but in this terrain you can't exactly hope to follow them."

But Englemeyer has managed to find five occupied nests for a survey that biologist Kim Nelson is conducting of marbled murrelets in Oregon. Although

Last June, the U.S. Fish and Wildlife Service proposed listing the marbled murrelet (Brachyramphus marmoratus) *as threatened. The murrelet lives at sea much of the year but nests in coastal forests of the Pacific Northwest. Nests were discovered only recently, the last to be found of all North American birds.*

GUS VAN VLIET

historical accounts record the occurrence of murrelets up and down the Oregon coast, Nelson has found that their present distribution is clumped along the coast in areas associated with coastal old-growth forests. "We see the largest concentrations at sea near the mouths of creeks and rivers that drain through older age forests," Nelson explains. "They use the creeks as open corridors to fly in and out of the forest."

Unlike other seabirds with their stark black and white plumage, during breeding season the marbled murrelet is a mottled, marbled brown that matches the bark of trees. The female lays a single egg, and shares incubation with the male in twenty-four-hour shifts. The chick is left alone within a day of hatching, and visited at dawn and dusk by a parent bearing food. This leaves the chick vulnerable to a number of dangers.

"I lost both my chicks last year," says Nelson. "One was blown out of the nest when the windbreak was removed in an adjacent clearcut; the other was taken by a great horned owl. Considering their slow reproductive rates, we can't afford these losses."

The greatest threat facing the marbled murrelet may be the continued loss and fragmentation of older-aged coastal forests. One third of the potential nest sites identified on National Forest lands in Oregon and Washington are scheduled for logging. Although recently proposed for threatened species listing by the U.S. Fish and Wildlife Service, their only designated protection is within the HCAs created for the northern spotted owl, and just how these areas will be managed remains in question.

"The HCAs were set up for the owl, surrounding existing owl pairs. They won't work for the murrelet," says Nelson. "They are too far inland, much farther inland than most murrelets go."

In California, C. John Ralph coordinates the marbled murrelet study from the Forest Service Redwood Sciences Laboratory in Arcata. He has found the occurrence of marbled murrelets exactly coincides with old-growth stands of coastal redwoods. The birds are found clumped offshore from the protected parkland in Humboldt and Del Norte counties and farther south in San Mateo and Santa Cruz counties. They are virtually absent from the cutover lands in between. Ralph reflects on this landscape pattern.

"The biggest difference between the coastal redwood forest and any other forest in the Pacific Northwest," he explains, "is that the redwood forest was championed early on by the Save the Redwoods League, which bought up the land, followed by the state of California and most recently the National Park Service. As a result we have in California the largest protected stands of old-growth coniferous forest in the Pacific Northwest outside of the Olympic Peninsula. Coastal Douglas fir and sitka spruce never had champions like that, and therefore they were taken down."

"We think of these old-growth species as being maladapted because they got themselves into an ecological tight spot. But heck, they were the generalists a thousand years ago," says Ralph. "They had most of the habitat of North America as their province. It was the second-growth species—the robins, the white-crowned sparrows, all of which are extremely abundant today—that were the rarer species a thousand years ago." The old-growth redwood forest that remains along Highway 101 in northern California is just a sample of what once mantled the coastline from Monterey Bay to the Rogue River. In fact, the protected pockets of giant trees from the California parks to the Olympic Peninsula include only one intact watershed. What is lost when a diverse forest ecosystem is converted to a cropland of trees is not just old-growth, but the complexity of the natural forest at all its stages.

"Each age class of a natural forest offers important habitat for some plant and wildlife species," says biologist Andrew Hansen. "There are some species, such as the western bluebird that thrive in young, naturally disturbed forests, just as there are species such as the spotted owl that depend on old-growth. In a young forest or in an old forest, structural diversity is the key to biodiversity."

A forest is structured from its limbs, its logs, its leaves and lichens, and in every detail the old-growth forest has variety and abundance. There are many different kinds of trees in the primeval forest, tall, short, young, and old. The canopy extends from the rooftop of crowns to a low ceiling of understory branches, a deep layer of insulation that keeps the forest cool in summer and warm in winter. Millions of needles comb moisture out of the clouds, harvesting as much as 30 percent additional precipitation to the forest.

Millennia of fires, floods, disease, and storms have sewn a patchwork into the Northwest landscape. Where a patch was disturbed, a young forest grew back among the survivors and the debris of the old forest. A legacy of microbes and symbiotic fungi were fostered in the soil by logs and resprouting roots. Pioneering plants, alders and willow among them, were often the nitrogen fixers enriching the forest soil for the later longer-lived species. Over the centuries of recovery, the forest added more logs and snags and old-growth trees to its structure.

Miles Hemstrom, forest ecologist for the Willamette National Forest, compares the old forest patterns with the new. "With timber management, the main emphasis has been on simplification. We focussed all the productivity of the site on growing young Douglas fir. We shortened up the early stage and we truncated the mature and old-growth stage. We cut off both ends of the forest's life and concentrated on the time when Douglas fir in particular produces the most wood fiber."

As a result, tree farms have a simplified structure, with limited wildlife habitat and ecosystem function. They are often

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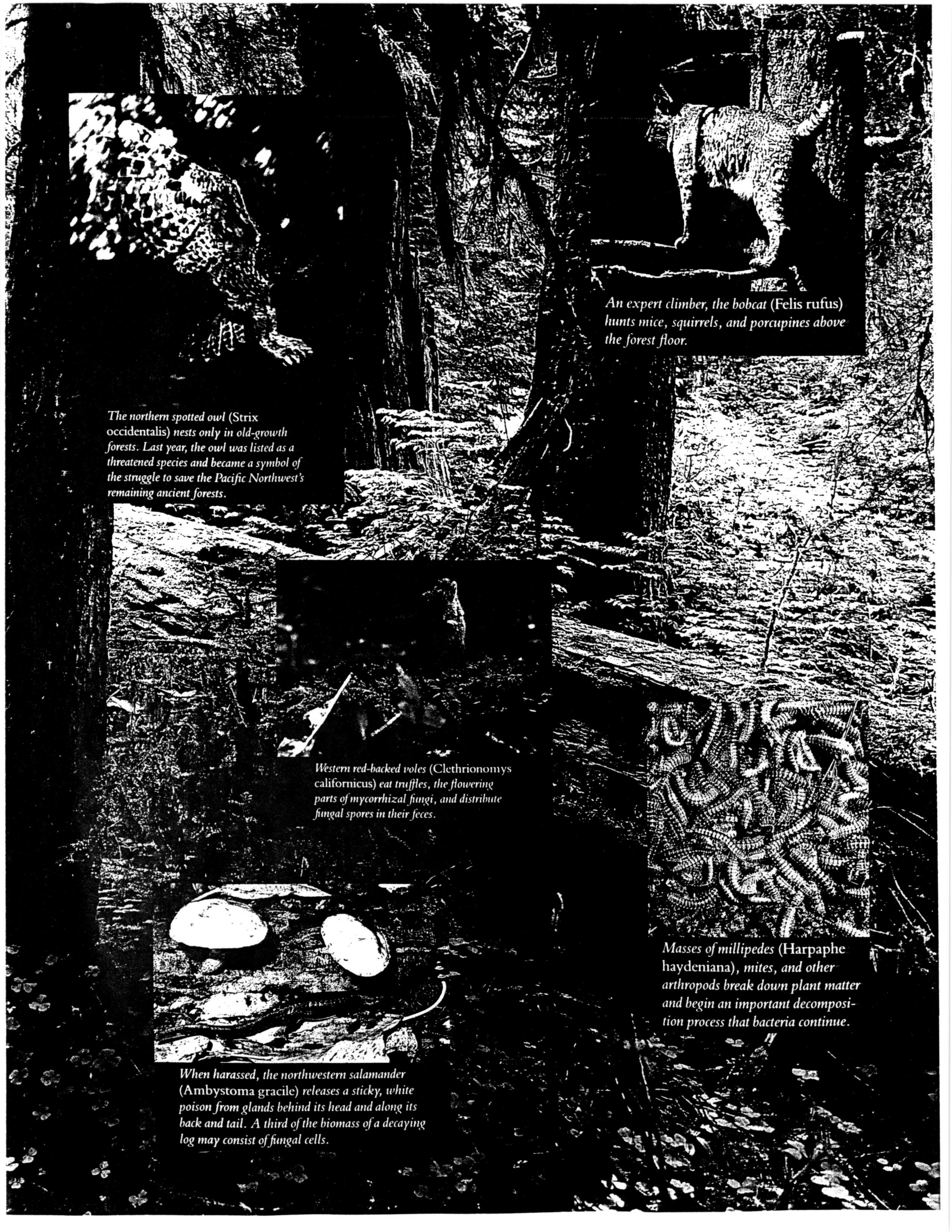
Often the most abundant lichen in old-growth trees, Lobaria oregana *sandwiches nitrogen-fixing cyanobacteria between its fungal and algal layers.*

Nodules filled with nitrogen-fixing bacteria cling to the roots of many forest trees, including this red alder. Alders and other pioneering species enrich the soil for the longer-lived trees that succeed them.



The northern spotted owl (Strix occidentalis) nests only in old-growth forests. Last year, the owl was listed as a threatened species and became a symbol of the struggle to save the Pacific Northwest's remaining ancient forests.

An expert climber, the bobcat (Felis rufus) hunts mice, squirrels, and porcupines above the forest floor.

Western red-backed voles (Clethrionomys californicus) eat truffles, the flowering parts of mycorrhizal fungi, and distribute fungal spores in their feces.

Masses of millipedes (Harpaphe haydeniana), mites, and other arthropods break down plant matter and begin an important decomposition process that bacteria continue.

When harassed, the northwestern salamander (Ambystoma gracile) releases a sticky, white poison from glands behind its head and along its back and tail. A third of the biomass of a decaying log may consist of fungal cells.

THE ENUMERATED FOREST

Number of species of conifer found in old-growth forests: 25

Number of plant species that may reside in one tree: 100

Number of species of fish and wildlife that flourish in ancient forests: 200

Number of invertebrate species that inhabit a single stand of ancient forest: 1,500

Number of species of arthropods estimated to inhabit the same stand: 8,000

Number of mites from a single sub-order, the oribatids, that can inhabit a square yard of forest: 200,000

Percentage of spotted owl nests in tree-top cavities and broken trunks of old-growth forests: 97

Number of years it takes for enough moss and lichen to grow on a tree's branches for the marbled murrelet to adopt the tree as a home: 150

Number of inches of fog drip wrung out of northern California redwood forests during the rainless summer months each year: 7-12

Number of years conservationists estimate it will take to destroy most of the remaining ancient forests at current rates of cutting: 20

Number of years the timber industry estimates: 60

Number of times U.S. Forest Service roads in ancient forests exceed the Interstate Highway System: 8

Acres of old-growth forests remaining in Washington and Oregon west of the Cascades: 2.4 million

Acres of second-growth forests in the same region: 18 million

Percentage of old-growth forests remaining in northern California and southern Oregon: 4

Percentage of all timber cut in Oregon and Washington in 1988 that was shipped overseas as whole logs, mainly to Korea, Japan, and China: 24

Number of days it takes to cut down a 56-acre stand of old-growth trees: 1

Average number of tons per acre of above ground biomass in old-growth Douglas fir/western hemlock forests: 386.6

Average tons per acre of all above ground flora in a mature tropical rainforest: 184.8

Sources: The Wilderness Society 2, 3, 10; National Wildlife Federation 13, 14; *The New York Times* 5, 6; Kelly & Braasch, *Secrets of the Old Growth Forests* 1, 4, 7, 15, 18, 19; Seth Zuckerman, *Saving the Ancient Forests* 8, 9, 10, 11, 12, 16, 17.

clearcut and scraped clean of structure or survivors. Their legacy of rich organic soil is burned out and baked by low-temperature fires in the leaf litter. Nitrogen-fixing broadleaf plants are sprayed with herbicides, and the bare, increasingly sterile ground is replanted with Douglas fir.

The northern Oregon coastal forest is one of the largest areas of intensely managed forests in the Pacific Northwest. Much of the native sitka spruce and western hemlock forest was cut as much as a century ago and transformed into huge planted tracts of Douglas fir. Stumps twelve feet across stand bleached and ghostlike in dark forests of even-aged plantations that are ready to cut again.

"What we've learned from timber management is how to produce a lot of wood fiber," says Hemstrom. "But these plantation forests are, at most, in their third rotation, so we still don't know what the cost will be to long-term site productivity."

BUT THERE ARE PLACES in the forest where the cost is becoming known. In the Klamath Mountains between California and Oregon are clearcut slopes that remain bare after repeated attempts to replant. Soil ecologists Dave Perry and Mike Amaranthus of the Andrews group examined one of the sites and found dramatic changes. The clearcut soil resembled sand, no longer laced together with fine strands of roots and mycorrhizal fungi as in the forest soil. The bare soil was awash with growth-inhibiting bacteria and impoverished of nourishing fungi and disease-fighting microbes. Apparently, when the trees were clearcut, the mycorrhizae lost their symbiotic partner, the soil community changed, and new trees could not grow.

There is much more to the life of this old forest than breaks the surface. Much of its biodiversity is underfoot, and not well understood. Andrew Moldenke, an entomologist with the Andrews group, points to my soggy boots, "Right now your foot is supported on the backs of 16,000 invertebrates."

The support system of healthy trees depends on the uptake of water and nutrients from the roots via the mycorrhizae. It is the decomposition of forest litter by fungi and bacteria that makes these nutrients available, and it is insects and other arthropods that carry these microscopic decomposers within their digestive tracts. Billions of tiny mites, centipedes, and spiders shred forest debris into progressively smaller pieces until the remains of fallen logs and needles are eventually recycled as nutrients to feed the roots of subsequent generations of forest plants.

The Andrews is the site of one of the most detailed investigations ever conducted on arthropod diversity and on the key role soil arthropods play in the long-term health of the forest.

"It is quite probable that the highest

RENEE LYNN

Reaching a foot in length, the Pacific giant salamander (Dicamptodon ensatus) *is a formidable forest predator, eating many invertebrates, such as this banana slug, lizards, other salamanders, and even small mammals.*

levels of terrestrial biodiversity anywhere on Earth occur in the soils of these temperate coniferous forests," Moldenke adds. He and his colleagues at the Andrews have reported densities of fungus-eating mites as high as 120,000 per square meter of soil.

The profusion of life underground is mirrored overhead in the canopy. Much of the Gothic feel of the old-growth comes from the abundance and variety of greenery. Enumerable variations of lichen, the symbiosis of fungi and algae, grow here. Because the algal partner needs sunlight to photosynthesize, lichens grow high in the forest canopy. One of the most abundant lichens is a bright green cabbage leaf, *Lobaria oregana.* Although sometimes unnoticed from the ground, its biomass often exceeds that of all other lichens, mosses, and liverworts growing in the trees. Sandwiched between the layers of fungus and alga in the *Lobaria* are nitrogen-fixing bacteria. The constant rain of *Lobaria* from canopy to floor provides the forest ecosystem with over half its input of fixed nitrogen. But the lichen grows slowly, occurring only in trees already well over a century old.

The raining *Lobaria* falls on a forest floor that is a wonderland of continuity. Our own lifespans are too short to easily understand the life and death of a forest tree, one that lives for five hundred years, then dies for another five hundred. The moment of death cannot be pinpointed, since in a standing green conifer only about ten percent of the cells are actually alive. In contrast, a fallen tree in an advanced state of decay harbors a whole community of living cells, 35 percent of its biomass may be fungal cells alone.

One of the more remarkable pieces of research at the Andrews Experimental Forest is a two-hundred-year-long study of dead wood. Mark Harmon, the first of a future dynasty of researchers on this project, has set out to describe the cycle of life, death, and rebirth that is acted out in a fallen log.

"I find it really curious and frustrating," says Harmon, "that in investigations of the global carbon budget there are no inventories that include dead wood, even though 80 percent of the biomass of the world is in woody material. When it's living, it's okay, but when it's dead—forget it.

"But here in the old-growth forest you can't ignore it, you trip over it wherever you go."

Here, dead wood is one of the strongest components of life. When it falls across a steep slope, it helps prevent erosion of soil. When it falls across a stream, it helps create stepped pools and stable banks. Logs often form a nursery bed for conifer seedlings. A colonnade of giant sitka spruce may mark the spot of a nurse log that fell centuries before. Within the jumble of logs criss-crossed over the forest floor is a lively community, a hotbed of biological activity.

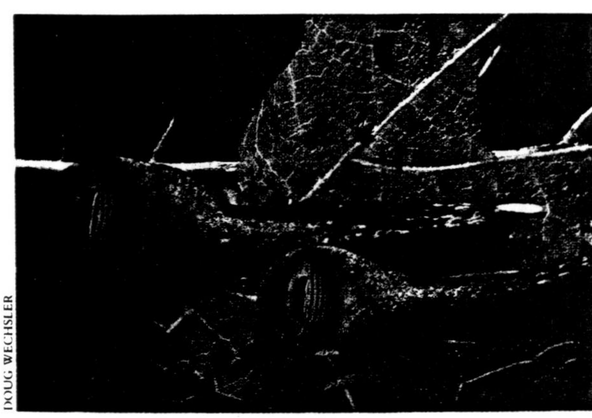
A downed log is quickly colonized by as many as 180 species of invertebrates. In a fermentation process not unlike that of a distillery, the log releases ethanol, an irresistible signal to beetles and others. Often most abundant are ambrosia beetles *(Xyleborus* spp.*)* numbering as many as one thousand individuals per square meter of wood, tunneling through the bark and carrying with them hitchhiking fungi, nematodes, and bacteria. As tunnels spread, carpenter ants, millipedes, and mites move in. During the long life of a log, its nutrient content increases. Nitrogen-fixing bacteria enrich the decaying wood, and mushrooms sprout and die, carrying nutrients to the surrounding soil.

In streams that drain the old-growth forests, logs build riffles, pools, and side channels that stairstep down the slope. Biologist Stan Gregory demonstrates the importance of these stream features to our group at the Andrews. Gregory stands boot-deep in a cascading, tumbling stream, and with a quick squirt of harmless fluorescent dye, he shows how the water swirls behind logs, lingers in plunge pools, and seems to be in no great hurry after all.

"It's friction from these rocks and logs in the stream that slows the water down, allows sediments and gravels to settle out, and creates habitat in all these little backwaters and eddies," Gregory explains.

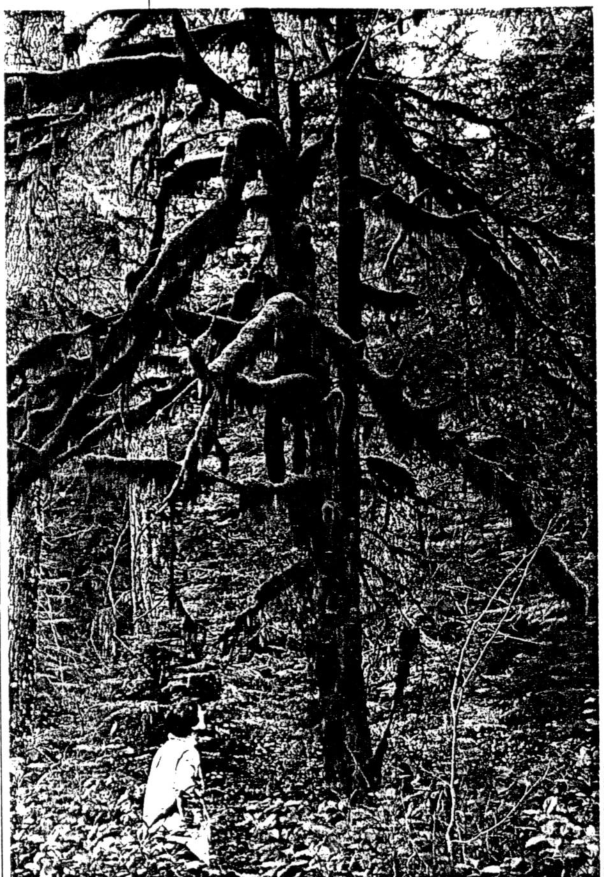
These little backwaters, alive with the larvae of stoneflies and caddisflies, are the hunting grounds for Pacific giant salamanders *(Dicamptodon ensatus),* endemic to old-growth forests, and for tailed frogs *(Ascaphus truei),* among the world's most primitive frogs. Clinging by their suction cup mouths to rocks in the swifter currents, the tadpoles of tailed frogs require several years to reach maturity. They also require a constant supply of cold, clear, tumbling water, attributes which are lost when the large trees and logs are removed.

Without structure to slow the water, riffles and pools would be scoured by torrential flows. Ecosystem studies conducted years ago at the Andrews showed how watersheds were damaged by clear-cutting. Subsequent work throughout the Northwest has linked logging practices with damaged salmon habitat and set the stage for another legal battle—saving the wild salmon (See *Pacific Discovery,* Spring 1991, page six).



DOUG WECHSLER

The primitive tailed frog (Ascaphus truei) *lives only in old-growth forests. The male frog's "tail" is a copulatory organ. The tadpoles have suckers that cling to rocks in streams.*



TROY WAYRYNEN

The bark and needles of the Pacific yew (Taxus brevifolia), *an old-growth forest conifer, yield a potent drug called taxol that may hold the key to curing a wide range of cancers. The growing demand for taxol threatens this species' survival.*

A Bark with Bite

WHILE CRIES OF "jobs vs. owls" and "forests forever" echo across old-growth stands in the Pacific Northwest, a new priority has quietly emerged. A little-known conifer that produces a powerful drug against cancer has moved onstage to share the conservation spotlight with the spotted owl.

The needles and the thin, purplish bark of this tree, the Pacific yew *(Taxus brevifolia)*, contain a compound called taxol. Taxol has proven effective in stopping ovarian and breast cancer where other treatments have failed. The National Cancer Institute (NCI) calls taxol "one of the most important cancer drugs discovered in the past decade." It all sounds like one of those miracle drug stories that are supposed to emerge from *tropical* forests.

But there's a problem. The Northwest forests harbor relatively few yews, and each holds only a little taxol. The amount of taxol in needles varies a lot and is difficult to obtain. And it takes between 20,000 and 30,000 pounds of yew bark—a few thousand trees—to make about two pounds of taxol, which can treat about five hundred patients. The bark from six one-hundred-year-old trees yields enough taxol for a single patient's treatment.

The yew's medical potential was discovered during an intensive NCI search of 35,000 plants for new drugs. Now taxol's therapeutic promise has set up an unlikely confrontation, pitting conservationists and forest scientists against medical researchers.

In the past two years, the demand for yew bark has skyrocketed. Woodcutters, fern pickers, and others who made their living gleaning from the forest turned to stripping yew bark to fill NCI's orders: sixty thousand pounds of bark in 1989, and again in 1990. While clinicians around the country were asking for increased supplies of taxol, NCI asked for statistics on bark availability in the Northwest forests. No one knows how many yews are left.

This year's order for yew bark increased twelve-fold, to 750,000 pounds. "We need the taxol right now," says NCI's Elaine Blume. NCI estimates that it will have a growing demand for yew bark in the next few years, and so far taxol is only offered to patients in clinical trials.

The slow-growing Pacific yew never attracted much attention from loggers. In fact, yews were generally cut down and burned during clearcuts. "I have a section of a yew tree right here on my desk that I collected off a slash pile a few years ago," says Chuck Bolsinger, principal resource analyst with the Pacific Northwest Research Station. "It's six inches in diameter and has 82 rings. A Douglas fir with 82 rings would be more than 30 inches in diameter." Bolsinger found most of the largest yews in old-growth stands, where the number of yews per acre averaged twice that found in second-growth stands.

Bolsinger recommends a cautious approach to harvesting the Pacific yew. It is one of few conifers that will sprout from its roots after fires and logging, so it can grow on cutover land. However, because of its slow growth, the yew cannot be sustained in forests managed for short rotation.

So far, the taxol molecule has eluded attempts to reproduce it in the lab from scratch. Robert Holton, a chemist at Florida State University, recently patented a semi-synthesis of taxol, but the procedure still requires starting with the most complex part of the molecule that can only be obtained from yew bark.

An alternative approach may spare the yew sooner and still meet the demand for taxol. Last year, ESCAgenetics, a biotechnology company in San Carlos, California, applied its techniques for making plant products such as vanilla and other flavors to the taxol problem. Starting with various parts of the yew, researchers nurtured cell tissue cultures in Petri dishes. The plant cells were then placed inside fermenters, where the cells converted sugars into the plant's normal secondary products, including taxol.

In June, ESCAgenetics announced that it had successfully made large amounts of taxol directly from the tissue cultures. "We won't have to go back to the trees anymore," says Walter Goldstein, the company's vice president for research and development. He says their taxol may be available for widespread use within two years.

Is a solution to the taxol dilemma near at hand? While the debate continues, weighing the cost of saving human lives against the cost of felling ancient trees, perhaps it's most important to consider what other undiscovered knowledge could be lost from the old-growth forests. □

—Blake Edgar and M. L. Herring

THE SALMON that reappeared each year in the coastal streams and rivers inspired powerful myths of immortality in the first Northwestern people. Today another species of the old-growth forest defies mortality. Standing in the shadows of the giant conifers, the Pacific yew (*Taxus brevifolia*) holds a cure for cancer in its bark (see sidebar, page 16).

The myths of many cultures have associated yew trees with mystery and death. Ancient Egyptians, Greeks, and Romans used parts of yews in funeral ceremonies. Victorians believed that in churchyards the roots of yews grew into the throats of the dead. In the Northwest forests, the long, drooping limbs shrouded in moss give the Pacific yew a wraithlike appearance. Its slim trunk rarely reaches 30 feet high. Needles are scarce along its branches and its seeds are borne singly in a fleshy, red cup. Its bark is purplish red and thin as a sheet.

Little was known, and few people cared, about the Pacific yew until scientists at the National Cancer Institute distilled the drug taxol from extracts taken from its bark. After more than ten years of tests, the Institute found taxol to be the most effective treatment for ovarian and other cancers and the Pacific yew was its most promising source.

Suddenly there was a great demand for yew trees. Despite a lack of inventories on Forest Service lands, a recent directive from the Forest Service reportedly mandates the harvest of 750,000 pounds of yew bark in 1991. Many forest scientists worry that the upcoming increase in yew harvests will mean stripping the future of Pacific yew in the Northwest forests.

HOW CAN ALL the values of the forest be preserved for the future? Miles Hemstrom explains part of the strategy being drafted in the Willamette National Forest: "We are trying to understand what patterns disturbance imposed on the forest, what patches it left and at what frequency. We are trying to find a way to manage forest stands and landscapes that will mimic that natural condition. As the debate goes on about the fate of the federal forests, we hope we can come up with alternatives that allow humans to be part of the landscape; a way we can coexist, extract some timber and other commodities, and yet as a primary focus, still maintain a functioning, diverse forest landscape."

The paradigms of forestry are shifting. Getting out the cut is giving way to saving biological diversity. The forest reserves from a century ago, the present wilderness areas, and Habitat Conservation Areas now being designed may not save the spotted owl, or the marbled murrelet, or the Pacific yew. We must first save the forest ecosystem, in all its diversity of structure and function. We must maintain a landscape of old trees, young trees, the majestic, as well as the obscure whose undiscovered value may hold the forest together or cure human disease.

As society awakens to the value of old-growth habitats pressures mount against the old saws of forestry. In an attempt to adapt, some in the Forest Service have suggested a new approach to harvesting the forests. Called "New Forestry," it accommodates many ideas developed at the Andrews Experimental Forest.

Advocates of New Forestry would abandon the practice of clearcutting. Instead, they would attempt to mimic patterns of natural disturbance—leaving in place some logs, snags, and living trees. This would provide the forest with a foundation on which to rebuild some of its original structure.

Logging industry critics argue that abandoning the old ways for New Forestry will cost as much as a 40-percent reduction in timber production and many in the industry are appalled at the thought of leaving any good logs lying in the forest to rot. On the other hand, many environmentalists are appalled that any cutting at all should be allowed in the old-growth forest. Although the long-term effectiveness and political viability of New Forestry remain untested, one thing is clear; we can no longer manage the forest for a single species—not just for Douglas fir, not just for the spotted owl. The forest must be managed for its entirety.

The storm reaches us finally at the edge of the forest. As the wind picks up and the rain beats harder, we step out to a clearcut where Douglas fir seedlings like Christmas-tree soldiers march away from the old-growth.

"Preservation by itself won't achieve biological diversity," Franklin warns the group. "We can't preserve enough land in the right places. We have to learn to incorporate stewardship in all the places where we grow our wood fiber, grow our crops, graze our cows, even where we live. In fact, incorporating ecological values and stewardship on the bulk of the planet's surface is what maintaining biological diversity is all about." □

M. L. HERRING, *who has worked as a biologist for the Oregon Department of Fish and Wildlife, now reports on and interprets environmental research throughout the West.*

ORGANIZATIONS CONCERNED WITH SAVING THE OLD-GROWTH FORESTS

Audubon Society, National Forest Issues, 801 Pennsylvania Avenue, SE, Washington, DC 20003, (202) 547-9009.

National Wildlife Federation, 519 SW 3rd Avenue, Portland, OR 97204, (503) 222-1429.

Northcoast Environmental Center, 879 9th Street, Arcata, CA 95521, (707) 822-6918.

Sierra Club, National Forest Issues, 330 Pennsylvania Avenue, SE, Washington, DC 20003, (202) 547-1144.

The Wilderness Society, 900 17th Street, NW, Washington, DC 20006-2596, (202) 833-2300.

The Xerces Society, 10 Southwest Ash Street, Portland, OR 97204, (503) 222-2788.

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