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EXPERIMENTAL FORESTS AND RANGES

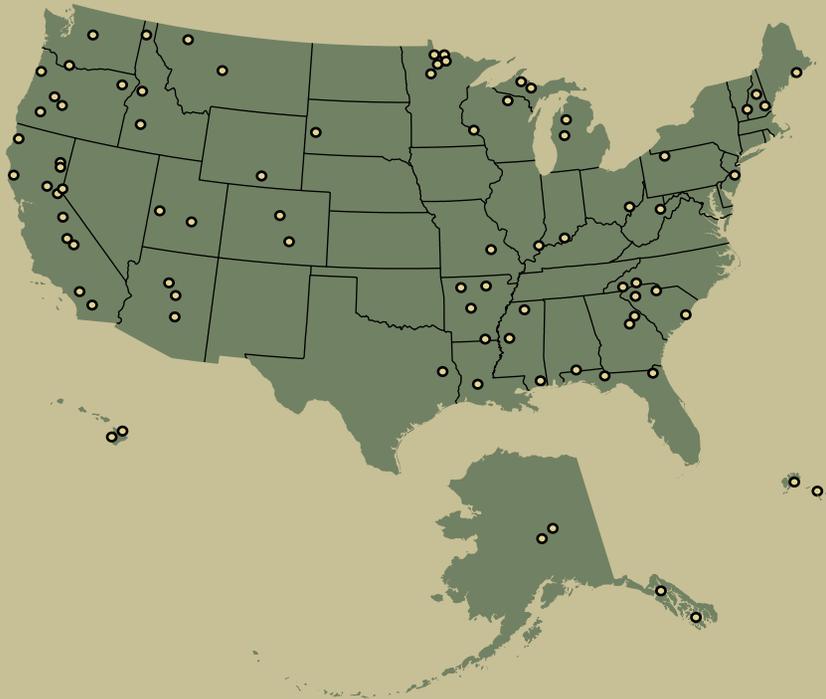


100 Years of Research Success Stories

Experimental Forests and Ranges
100 Years of Research Success Stories

Gail Wells

Gail Wells Communication.



Experimental forests and ranges
across the nation.

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*“...and all those selfless souls who kept conducting excellent research on Experimental
Forests and Ranges throughout the years.”*



Foreword

Long-term research is the foundation of Forest Service Research and Development. I am pleased to introduce some of the scenery behind this research story—a historic network of experimental forest and ranges. *Experimental Forests and Ranges: 100 Years of Research Success Stories* overviews a century of research by dedicated Forest Service scientists, research that forms the scientific basis for much of present and future forest management.

The 14 vignettes in this publication are only part of the larger story. The USDA Forest Service maintains 81 Experimental Forests and Ranges across the United States and in Puerto Rico. These valuable scientific resources incorporate a broad range of climates, forest types, research emphases, and history. They serve as living laboratories where Forest Service scientists not only learn but also share results with cooperators and stakeholders. Long-term records on many of these lands date back to the 1930s, when 29 of the 81 experimental forests and ranges were established. They provide an opportunity to conduct the bold, imaginative research required for a future with natural resources issues such as global climate change, watershed function, invasive plants, recovery after natural disturbances, among others.

As an ecologist and biogeochemist, I have often reflected on the contributions to watershed research coming from the experimental forests that I have more personal experience with, namely Coweeta, H.J. Andrews, and Hubbard Brook. This publication does not cover all, the oldest, or the most famous of our historic forests and ranges. It offers a few snapshots of research—old and new—on land areas that will continue to provide knowledge to address new questions and needs of society. We present these stories to illustrate something of the scientific resource and public benefit represented by this special segment of public lands.

I acknowledge the many contributors to this publication along with the scientists, technicians, and staff who are bringing this research to fruition. Their dedication, enthusiasm, and passion for these experimental forests and ranges are the real stories behind these living laboratories. This publication touches on some of their historic achievements and the pathways they opened for today's work. In the next century, today's scientists will continue this important and exciting work to solve some of the most vexing natural resource problems that we face.

A handwritten signature in black ink, reading "Ann M. Bentz".

Deputy Chief of Research and Development

The land cannot speak, but it can communicate. A change in the flow of a stream, the timing of bud break on a sycamore tree, the rate at which shrubs come in after a wildfire—all these are messages people can read if they know the language. That language is science.



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Introduction

100 Years of Success Stories from Experimental Forests and Ranges—Reading the Language of the Land

For a century, scientists of the USDA Forest Service have been reading the language of the land on a comprehensive network of experimental forests and ranges. These 81 sites encompass a rich variety of forest and grassland ecosystems across the United States and Puerto Rico. They range from boreal forest to tropical forest to peat-bog deciduous forest (Marcell Experimental Forest in Minnesota) to semi-arid chaparral (San Dimas Experimental Forest in California) to dry desert (Desert Experimental Range in Utah).

In 2008, Forest Service Research and Development celebrated the Centennial Anniversary of these Experimental Forests and Ranges. This publication celebrates the many scientists who over the course of decades conducted the long-term studies that began and are continuing to shed light on important natural resource issues. Story suggestions were solicited from the Experimental Forest and Range Working Group and were selected to demonstrate the array of research issues being addressed on these living laboratories. Gathering a wealth of information from her interviews with scientists, Gail Wells proceeded to write these “...wonderful success stories from 100 years of research.”

Studies established decades ago on many of these sites are still going strong. Experimental forests and ranges provide a valuable, long-term stream of information about the land and its resources. Over the years, researchers have built an impressive body of science to support good land management and further understanding of natural processes. Their research sheds light on many important questions. These experimental forests serve as living laboratories that help us connect the future to the past.

Silviculture: Many Forest Service management regimes have been based on knowledge gained from experimental forests. Much of what is known about old-growth structure and function came from studies on the H.J. Andrews Experimental Forest in Oregon and the Wind River Experimental Forest in Washington. Current research is conveying knowledge of old growth into management of young forests, including plantations. Loblolly pine management techniques were pioneered on the Crossett Experimental Forest in Arkansas; and impacts of diameter-limit cuts were developed on the Penobscot Experimental Forest in Maine.

Water: Forests play a critical role in their relationship with watersheds, and many watershed management strategies came from research on the experimental forests. The H.J. Andrews Experimental Forest was one of the first to examine the relationship between forest ecology and watershed function. The Caspar Creek Experimental Forest in

California has yielded key information on how logging on steep slopes and riparian areas can impact sediment flows on watersheds. Research from the Fernow Experimental Forest in West Virginia demonstrated the effects of acid rain on forest soils, streams, and vegetation and ways to mitigate acid rain.

Fire: A 2002 wildfire on the Blacks Mountain Experimental Forest helped researchers see the true effects of forest thinning—the fire dropped to the ground when it reached research plots that had previously been thinned. Research conducted on the Tenderfoot Creek Experimental Forest helped increase understanding of the relationship between fire, water, and forest ecology.

Grasslands: Early trials to rehabilitate ranges on the Desert Experimental Range in Utah helped pioneer the discipline of range management.

Soil Erosion: Long-term studies on the San Dimas Experimental Forest helped to answer important questions such as what people can and cannot do about landslides, floods, and wildfires that characterize chaparral watersheds in California.

Climate Change: The Marcell Experimental Forest in Minnesota has helped demonstrate the role of forests in mitigating climate change through measurements of carbon flux into and out of peatland forests.

Hardwood Regeneration: The Bent Creek Experimental Forest in North Carolina was the site of some of the earliest experiments on regeneration of hardwood species on degraded land after extensive logging. Many other experimental forests have contributed to a rich body of knowledge about regenerating forests.

Like the land itself, scientific capacity is a resource that needs stewardship. Over the past century, the Forest Service’s experimental forest and range network has been utilized to deepen our understanding of problems confronting society and the natural world—global climate change, species extinction, water quality and quantity, ecosystem degradation, invasive plants and animals. To be good stewards of the land, we need to understand the language of the land. The following success stories describe some lessons learned from interpreting the language of the land from this network of experimental forests and ranges. As the Forest Service celebrates the centennial of this outstanding network, the emphasis is on continuing this stewardship into its second century.

Loblolly Pine, the Miracle Tree

If it weren't for the chiggers, ticks, and poisonous snakes, the teeming lushness of a loblolly–shortleaf pine forest might be considered almost Edenic. These forests cover 10 million hectares (25 million acres) of western Gulf coastal plain, a rough carpet of lifeforms jostling for light, space, and moisture.

The most enthusiastic jostler of the bunch is the loblolly pine itself, thrusting its crown above a shoulder-high tangle of understory that includes poison ivy, honeysuckle, Jessamine, muscadine grape, rattan, and assorted prickly shrubs and vines.

“Loblolly is a miracle tree,” declares Jim Guldin, project leader at Crossett Experimental Forest. Guldin has near-evangelical enthusiasm for the qualities of this sturdy conifer. Loblolly pine is a prolific cone producer, a reliable seeder, a fast grower, a generous wood producer, and a hardy dominator of practically any site it's growing on.

Most remarkable of all, says Guldin, is the way loblolly can bounce back from a near-death experience. A stand of loblolly reduced to a bare one-third of its former abundance of trees—“that's a stand that looks like a tornado has hit it, which is often the case”—can be restored to its full glory in 15 years with the right silviculture.

“These forests have a tremendous innate fruitfulness, which makes using a variety of reproduction cutting methods very easy to do,” Guldin says. “It's nice to be working in a silvicultural laboratory where the major species is so productive.”

Because most of the forestland in the South is held by private non-industrial owners, sustainable and profitable timber management is important not only to landowners but to the Southern economy. Seventy-five years of Crossett research have proved that an owner can harvest a continuous flow of timber from a small tract of loblolly–shortleaf pines, all the while keeping the land forested, beautiful, and hospitable to wildlife.

Timber has been the economic heartbeat of much of the rural South for more than 100 years. The Crossett Experimental Forest was formally established in 1934 when the Crossett Lumber Company, owner of thousands of hectares (thousands of acres) of timber in southern Arkansas and northern Louisiana, leased 680 hectares (1,680 acres) of its cutover timberland to the Forest Service for a research station. The company needed scientific



Scientist Guldin points to stand condition in the uneven age “Poor Forty” in 2008, after 72 years of continuous management.

support for managing the second-growth timber that was springing up on its logged lands.

The Crossett Lumber Company was one of the largest of many that flourished in the South toward the end of the 19th century, logging the old-growth longleaf, loblolly, and shortleaf pine forests that covered hundreds of thousands of hectares (thousands of square miles) from the Ouachita and Ozark mountains to the flatlands of the Atlantic and Gulf coastal plains. By the 1930s, the old-growth forest was almost gone, and most companies had either folded or moved to richer pickings on the West Coast.

The Crossett Lumber Company was one of the few that stayed. It sold what land it could, tried unsuccessfully to convert some to ranchland, and finally resolved to learn how to manage its second-growth timber—a forward-looking idea at the time, considering that second-growth logs were considered low-quality material hardly worth milling.

In 1912, a Yale forestry professor, H.H. Chapman, came down to Crossett with some of his students. They inventoried the Crossett lands and assessed their regrowth potential. Chapman proposed the foundations of Crossett's forestry program, and the company took his suggestions to heart—extending its logging railroad into second-growth stands, hiring a forester, and adopting a policy of leaving seed trees on logged sites.

In 1933, the Forest Service assigned Russ Reynolds, a recent graduate of the University of Michigan's School of Forestry, to work with the Crossett



Lumber Company. One of Reynolds's first studies demonstrated that smaller second-growth logs could be profitably yarded with horses and hauled with trucks—truck hauling was just then becoming practical as local roads improved. The success of these initial efforts eventually led to the establishment of the Crossett Experimental Forest, which became home to Reynolds and his family in 1936.

In 1937 Reynolds began Crossett's Farm Forestry study in uneven-aged forestry, choosing two 16-hectare (40-acre) plots that became known as the Good Forty and the Poor Forty. Both these parcels had been heavily logged about 1920 without any thought toward regeneration and had recovered at different rates. "The Good Forty had good stocking of about 5,000 board feet of pine timber to the acre in 1937," says Guldin, whereas the Poor Forty had less than half that amount. But trees still grew on the cutover land, and loblolly seedlings sprouted like mushrooms each spring. ("God bless loblolly pine," Guldin says fervently. "There's always more regeneration than we know what to do with.")

Reynolds set up his trials of group and single-tree selection silviculture on both parcels, aggressively controlling the competing trees and shrubs and cultivating the prolific natural regeneration. "By 1951," says Guldin, "after 15 years of management, both the Good Forty and the Poor Forty were producing between 350 and 400 board feet per acre per year" in harvests every 5 years.

The Good and Poor Forty findings have been confirmed with statistical rigor in replicated experiments that Reynolds set up a few years later. They've also been confirmed with the record of time through seven decades of repeated measurements.

The Farm Forestry research showed conclusively that owners of small tracts of loblolly and shortleaf pine could manage their land profitably without clearcutting it—even if the forest is damaged from overcutting, ice storms, high winds, or pine beetles.

For instance, a 16-hectare (40-acre) loblolly stand, managed with any of several variants of selection harvesting, and logged every five years, can yield 2.5 m³ per hectare (400 board feet per acre) of pine timber per year. That's about 40 m³ (16,000 board feet) off the parcel every year, "or, put another way, five really big piles of timber," says Guldin. As a photo opportunity and graphic demonstration, Russ Reynolds liked to pile a year's yield of timber from the Crossett's Good Forty in the yard behind the headquarters and invite visitors in to admire it.



Logs in 1956 photo show one year of harvest, which is equivalent to the annual growth from the 16-hectare "Good Forty" (seen in the background).

The message of the Farm Forestry study, in keeping with its Depression-era roots, is that conservative forest management can pay off. "By cutting less than what's possible," says Guldin, "you can recover those stands to high-quality sawlog production quicker than if you clearcut." Most landowners can't afford a big up-front investment in replanting anyway, and with loblolly's spectacular regeneration potential, they don't need to, says Guldin. "Why look a gift horse in the mouth?"

Crossett's research legacy has not always been appreciated. When Russ Reynolds retired in 1969, the experimental forest was closed because many believed that plantation-type silviculture was the wave of the future and uneven-aged methods belonged in history's dustbin.

The shutdown might have been permanent but for a clause in Crossett's lease: the land had to be used for research or the company would take it back. Crossett Lumber Company had been absorbed by Georgia-Pacific in 1962, and G-P announced that it would take the land back unless research resumed. The Forest Service reversed its decision, and Crossett Experimental Forest was back in business by 1979.

The miracle trees kept on growing through the hiatus, and today Crossett has the most complete long-term data on growth and yield of naturally regenerated loblolly-shortleaf pine stands in the South. Crossett's work continues to be relevant to managed forests throughout the South—not only on private lands, but also on public lands such as national forests, where values such as wildlife and aesthetics are often as important as timber.

Leaving Something to Grow On

Imagine a pretty forest tract owned by two brothers in Maine. It's a mixed forest of red spruce, balsam fir, eastern hemlock, and eastern white pine, interspersed with red maples, birches, and aspens. This composition is typical of the Acadian Forest (the name comes from the early French settlers), a transitional eastern broadleaf/northern boreal forest that is widespread across the region.

Now imagine that the two brothers divide the tract between them and prepare to do a selection harvest. Each brother wants to leave some of the forest on the ground. One brother goes into his half and takes all the biggest trees.

The other brother takes his time and thinks about his objectives. He may take a few big trees and a few more medium-sized ones, paying attention to spacing. He may remove patches of aspen or birch so that spruce and hemlock seedlings can get established. He may remove the low-vigor or poor-quality trees, whether large or small.

In short, the first brother focuses on what to take, while the second focuses on what to leave.

After the brothers are done, their woods don't look much different to the neighbors. But these forests have been set on diverging pathways, and after 50 years and a few more harvests, even a casual observer will notice that Brother #1's forest doesn't look so good, while Brother #2's forest is healthy and vigorous.



Poor-quality and low-vigor trees, non-commercial species, and clumps and voids of vegetation are common occurrences in the diameter-limit cut stands after three harvests.



Selection cutting has maintained complex forest structures and compositions while improving tree growth and regeneration.

It all comes down to harvest method, says Laura Kenefic, research forester and principal silviculturist at the Penobscot Experimental Forest in Maine. Brother #1's method, termed diameter-limit cutting or "logger's choice," has been standard practice in the forests of the Northeast for 300 years, ever since colonists began harvesting masts for the British navy. Diameter-limit cutting (DLC) is considered a form of high-grading, which means taking the best and most valuable trees first.

"As a harvesting method, it's appealing," Kenefic says, "because it's so simple—if a tree is bigger than a certain size, you cut it." It is also appealing because it yields immediate revenue.

And initially, at least, it doesn't seem to do any harm. "From a landowner perspective, a long-term vision is about one human life span," says Penobscot project leader John Brissette. "So people don't realize what they're doing. There's a tendency to say, 'We cut over this thousand acres; we'll just move on and let the forest heal on its own.'" The problem is that the forest doesn't heal itself, because the diameter-limit harvests systematically strip it of its best trees.

Kenefic and Brissette have documented startling results from a 56-year-old experiment, a side-by-side comparison of DLC with various levels of selection and shelterwood harvesting based on silvicultural principles.



The selection cuts (an uneven-aged management method) were done with the aim of maintaining a wide distribution of tree sizes and improving the quality of the merchantable trees. The shelterwood harvests (an even-aged method), scheduled for a 100-year rotation, involved taking some of the trees, leaving others behind to shelter the new seedlings, and then removing the rest of the big trees. Some plots were left alone as a control.

After 56 years and three harvests, the silviculturally managed plots have the most diverse and productive forests, with thick canopies and an abundance of vigorously growing conifer trees with good age and size distributions. The DLC plots have smaller trees overall, slower-growing trees, many small unmerchantable and damaged trees, more gaps and patches on the ground, and a thinner canopy.

For many landowners, seeing is believing, says Keith Kanoti, landowner assistance forester for the Maine Forest Service. “When they look at the pictures, they’re amazed that the 10-year selection [one of the selection-harvest trials] looks as beautiful as it does—with multiple layers, light filtering through small canopy openings, vigorous healthy trees—because trees have been harvested there every 10 years for the last 50 years.” The contrast with the degraded DLC stands “allows them to see that there really are a lot of different ways to do things in the woods.”

Not only are the well-managed forests prettier after 56 years, they’re also more valuable, because the harvest was designed to keep high-quality trees growing all the time. By contrast, in the DLC plots, Kenefic says, “we found that value per harvested tree got lower over time.” That’s because the most valuable trees were gone after the first cut, so subsequent harvests have to take more small, low-value trees to get the same volume.

Kenefic and Brissette are currently studying ways to rehabilitate a stand degraded by repeated diameter-limit cuts. “But management options are limited,” says Kenefic.

None of this is really surprising. Anecdotal evidence has long held that high-grading is bad for forests. But the Penobscot experiment, which is both long-term and statistically rigorous, is the first to make a conclusive case. Says Kenefic, “Now we have data to persuade people to apply sustainable forestry practices instead of diameter-limit cutting.”

The Penobscot findings, says Kanoti, should interest two kinds of landowners in particular: those who want to make money right away, and those who don’t want to harvest at all for fear of losing their forest’s scenic value. The study, he says, is “a powerful tool to inform landowners that there are options that can generate revenue for them quickly, yet leave a good forest legacy for their children.”



Researchers in the 1950s initiated a variety of treatments, resulting in greatly differing forest conditions today.

A Counterweight to Hubris

Three generations of scientists have left their mark on the Wind River Experimental Forest. Each was striving to answer the important questions of the day, and each left behind a wealth of data, a legacy for those who followed.

Thornton T. Munger installed the first studies at Wind River nearly 100 years ago. His work on the basic ecology and management of Douglas-fir led to techniques for managing it profitably through a replanting and second rotation. His work helped prove that the timber business could profit by turning from destructive, cut-out-and-get-out ways and embracing long-term land stewardship.

The second generation at Wind River took the early, basic silvicultural work into the technological age. To help meet the booming post-World War II demand for lumber, Leo Isaac, Roy Silen, Robert Tarrant, George Staebler, and others developed management techniques for growing trees quickly and efficiently.

The third generation of scientists faced a different social imperative—concern about overuse and degradation of forests, especially old-growth forests. For Jerry Franklin, Dean DeBell, Tom Spies, and others working from the 1970s through the end of the century, the task was to find ways to manage forests more the way nature does.

Now a fourth generation is coming on, and a new concern has emerged: global climate change. Today's researchers are taking measurements of carbon from the air and soil, and they're studying the canopies of old-growth forests from a basket dangling from Wind River's famous canopy crane.

The one constant amid the shifting social questions and research agendas has been the forest itself. Not that things have stayed the same there—the forest has grown and changed through time too. But the knowledge gained through these long-term investigations has become a priceless resource. “This is a place that is protected in space and through time,” says Peg Herring. “That gives us the opportunity to learn things we could never learn without it.”

Herring, a science writer, is coauthor, with Sarah Greene, of *Forest of Time*, a 2007 history of the Wind River Experimental Forest. “The research questions don't remain constant,” says Greene, a forest ecologist and the recently retired manager of Wind River, “and so there's an ebb and flow to how



Munger using calipers to remeasure a permanent plot.

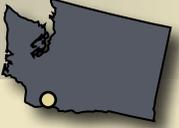
much [a single experimental forest] is contributing at any given moment to the important topics of the day. But you still have the place, and you still have the long-term data sets.”

Thornton T. Munger clearly had longevity in mind when he installed the first permanent Douglas-fir study plots at Wind River in 1910. Munger, a young New Englander who had come west to study ponderosa pine, quickly realized that Douglas-fir was the commercial species of greatest importance west of the Cascades. He saw, too, that wildfires and destructive logging were making a sustainable timber industry impossible.

Munger began his work in a hilly, fire-scarred, multi-aged forest near the Wind River in south-central Washington. He located stands of successive ages—40, 50, 60, 70, 80 years—and began measuring them to determine their pattern of growth decade by decade. He found that Douglas-firs not only grow fast, but add wood in a predictable pattern through time. That meant it was possible to calculate rates of return from an investment in reforestation.

To document his hypothesis, Munger established 0.4-hectare (1-acre) permanent growth plots in young forests at Wind River and elsewhere in western Washington and Oregon. He measured every tree larger than 64 millimeters (2.5 inches) in every plot and set up a study plan to continue the measurements in perpetuity. Although some of Munger's plots have succumbed to logging or blowdown over the years, the remaining ones are still being measured by Wind River scientists.

Munger and colleagues Julius Hofmann, Leo Isaac, and other early researchers conducted studies on every aspect of Douglas-fir management: tree



heredity, matching of seed sources to the planting site, spacing of seedlings, thinning, pruning, fertilization, weed control, and cultivation of nursery seedlings. Leo Isaac in particular made significant advances in knowledge of natural reproduction in Douglas-fir, and his work is still being used today.

Munger also established an arboretum for testing the growth of exotic tree species. He also set aside a 480-hectare (1,180-acre) patch of old-growth forest as a research natural area, so scientists could observe how Douglas-fir forests grow in the absence of management.

In the process of doing their science, these researchers amassed a large body of data about Douglas-fir—knowledge that is now so common it is taken for granted. “Lots of things seem obvious now that weren’t obvious then,” says Greene.

The second generation of scientists built on the findings of Munger, Isaac, and the others. Working during the boom times between the end of World War II and the mid-1970s, they developed silvicultural and harvesting techniques to grow timber as quickly and efficiently as possible, which was the priority of the day.

The third generation, concerned with the ecological functioning of the forest, also drew on Wind River’s growing legacy of data for their studies of wildlife habitat characteristics, the roles of fungi and mites and spiders, and the effects of canopy gaps, among many others.

That legacy has not always been appreciated. In the mid-1980s, Wind River scientists were directed to pull the plug on Munger’s permanent plots. They were too expensive and time-consuming to maintain, the rationale was, and surely there was nothing more to learn from them. But the scientists went on taking the readings anyway, “and that was good,” says Herring, “because those data were needed later.”

The longevity of an experimental forest, she says, provides a bracing perspective amid short-term jolts such as a booming housing market or a spate of environmental lawsuits. “It’s always tempting to assume we’ve found the answer and don’t need the data any more,” she says. “But an experimental forest is a counterweight to hubris. The questions may change, and the social setting may change, but we’re never done learning.”

Herring, Margaret; Greene, Sarah. 2007. *Forest of Time: A Century of Science at the Wind River Experimental Forest*. Oregon State University Press, Corvallis, OR.



Researchers taking twig samples in the upper canopy of an old-growth western redcedar.

Out of the Comfort Zone

It took a perfect storm of distinctive geography, a politically fraught research agenda, and proximity to a research university (Oregon State University, in Corvallis) to turn the H.J. Andrews Experimental Forest away from a narrow focus on commercially logged watersheds and toward an interdisciplinary program of ecosystem science.

The Andrews Forest is part of the vast, productive Douglas-fir region of the Pacific Northwest, where forests have shaped the region's economy and way of life. In recent decades, forests have been a battleground in a cultural war over environmental protection. It's been observed that forest management in Douglas-fir country can be a combat sport, and the Andrews Forest's research on old growth, stream ecology, and wood decay has exposed its scientists to both public acclaim and public wrath.

In their recent histories of the Andrews Forest, Max Geier (*Necessary Work*, 2007) and Jon Luoma (*The Hidden Forest*, 2006) portray it as a crossroads where experts on forest ecology, silviculture, soils, wildlife, fish, streams, and landscape dynamics push themselves out of their disciplinary comfort zones. The forest has become a natural and human environment that links "people, place, and community with an emerging vision of ecosystem management," in Geier's words.

This vision, says Fred Swanson, might seem inevitable in hindsight, but it was mostly the product of a succession of rewarding accidents. Swanson, a research geologist who recently stepped down as Andrews Forest lead scientist, joined the International Biological Programme at the Andrews Forest in 1972, as ecosystem science was just beginning there.

The coniferous forests of the western United States have three (at least) distinctive native features: big, old trees; cold, fast streams; and lots of dead wood. These are topics that lend themselves to interdisciplinary research anywhere. It happened that, in western Oregon in the 1970s, they also were harbingers of a brewing environmental war. "We didn't set out to study old growth," Swanson says. "We studied old growth because that's what was here."

When the Andrews Forest was dedicated in 1948, the main purpose of its research was to quantify the effects of commercial logging on watersheds and find ways to mitigate its environmental impacts, especially on stream flow and water quality. It was a time when enlightened management philosophy called for liquidation of "decadent" old-growth forests to make room for fast-growing, "thrifty" plantations.



A snowy winter day at the Mack Creek gauging station within the Andrews forest.

Then, in the mid-1960s, that philosophy began to shift. Andrews Forest researchers, led by forest scientist Jerry Franklin and soil scientist Ted Dyrness, questioned the assumption that old-growth forest was nothing but overripe timber. (This story has been told in colorful detail in Geier, Luoma, and elsewhere.) The work of these scientists began to reveal old forests for what they are: complex ecosystems with processes of living and dying going on all the way from soil microorganisms to lichens at the tops of the tallest trees.

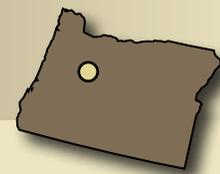
The Andrews "Stream Team," first led by aquatic ecologist Jim Sedell and later by Stan Gregory, began probing the function of wood jams commonly found in old-growth forest streams. Common wisdom, backed by the latest fisheries research, said dead wood choked the stream and blocked passage for the fish. So loggers were routinely (and expensively) hauling all wood out of streams after a logging operation, even the pieces that had been there before.

The Stream Team turned common wisdom on its head. Their studies showed that dead wood provides calm pools where fish can rest, gravel bars for spawning, and cover from predators. And it harbors insects fish need for food.

The Stream Team's work was first featured at a major 1975 conference that brought together scientists, forest managers, loggers, and timberland owners. There followed a rapid about-face in standard forest practices. This marked one of many translations of Andrews research into policy.

If dead wood is ecologically valuable in the water, shouldn't it be just as valuable on land? Mark Harmon, a forest ecologist at Oregon State University, began a remarkable experiment in 1985 to look at decomposition processes in dead logs at the Andrews—more than 500 of them, carefully chosen to be free of defects and to represent a broad range of decay rates.

Harmon designed his research to last 200 years, which garnered him skepticism and even derision from some colleagues. There was also hostility from the neighboring town of Blue River, which, like many Oregon timber towns at the time, was suffering economically. It galled some people to see perfectly good logs rotting on the ground.



But Harmon's careful study design won the respect of colleagues, and his gentle explanations to the forest workers—the loggers who felled the trees and the equipment operators who placed the logs—smoothed the waters with the neighbors. The study prompted Harmon to coin a whimsical new term, “morticulture.” The word, says Swanson, “crystallizes the importance of a science for management of dead wood to parallel the science of silviculture for managing the living parts of a forest.” Two decades in, Harmon's study has begun to yield important findings about the role of dead wood in wildlife habitat, carbon dynamics, and nutrient cycling.

Andrews Forest research has continued to influence public policy. A major example is the ecosystem science that went into the conservation plan for the northern spotted owl, listed as threatened in 1990, and eventually into the Northwest Forest Plan. Another is the 1990 paper (Harmon was the lead author) showing that cutting old forests and replacing them with new ones would *raise* carbon output into the atmosphere, not lower it as some political leaders were claiming.

The Andrews Forest is collaborating with sister experimental forests to function more as a true research network. “Surprisingly, there's been very limited networking among experimental forests until now,” says Sherri Johnson, a stream ecologist and the Andrews's lead Forest Service scientist. “We are beginning collaborations that build on research findings from individual sites.”

The Andrews Forest is also the base of a close research-management partnership with the Willamette National Forest, within which it is situated. The partnership carries out communications programs and studies of landscape-scale management and management of young plantations. For these reasons the site was designated the Central Cascades Adaptive Management Area in the 1994 Northwest Forest Plan to function as a testing ground for a range of management strategies.

None of these accomplishments would have been possible, says Fred Swanson, without a long-term relationship with the land. “We can carry out planned learning through hypothesis testing with experiments, but totally surprising discoveries are tremendously important, too. Because of this long-term relationship with place and one another, we can look back and say, ‘Wow! Look at all those serendipitous lessons we learned!’”

Geier, Max. 2007. *Necessary Work: Discovering Old Forests, New Outlooks, and Community on the H. J. Andrews Experimental Forest, 1948-2000*. USDA Forest Service Pacific Northwest Research Station, General Technical Report PNW-GTR-687, Portland, OR.

Luoma, Jon. 2006. *The Hidden Forest: Biography of an Ecosystem*. Oregon State University Press, Corvallis, OR.



Lookout Creek flowing past old-growth Douglas-fir and western redcedar in the Andrews forest.

The Effects Go On and On

Between 1963 and 1967, researchers at Caspar Creek Experimental Watershed made preliminary measurements for a paired-watershed logging study on California's redwood coast. The effects of logging would be identified by comparing flow and sediment measurements from a logged watershed with those from a similar, unlogged watershed.

The study site was a wet coastal forest that had been logged around the end of the 19th century and was now covered with fast-growing 90-year-old redwoods. The study would document the effects of a tractor-yarded selection harvest on the South Fork of Caspar Creek that would take out about two-thirds of the timber. (In tractor yarding, the logs are dragged out of the woods by a bulldozer.) The operation would start with extensive road-building.

Researchers expected that the South Fork operation would have a substantial effect on the landscape of the 400-hectare (1,000-acre) watershed. And when the operation took place between 1967 and 1972, indeed, it hit the watershed pretty hard. Sediment more than tripled from the road-building in 1968, and then doubled again when the site was tractor-logged from 1970 to 1973. Major post-logging landslides occurred, peak streamflows increased, and numbers of coho salmon in the South Fork declined.

The magnitude of the effects was not a surprise to those early researchers, says Liz Keppeler, a hydrologist who oversees the research at Caspar Creek. In the 1960s and early 1970s, logging operations were mostly unconstrained by the kinds of protective rules taken for granted today. "There were no requirements to leave a buffer along the stream, for example," she says. "You could even drive a bulldozer in the streambed, and they did."

The researchers did expect peak streamflows and sediment to settle back to pre-logging levels relatively quickly. These expectations also seemed reasonable, and after a few years they seemed to be coming to pass: streamflows and sediment levels in the South Fork were declining, and salmon numbers seemed to be rebounding.

In 1985, with recovery from the South Fork logging well underway, the scientists moved on to a second watershed-scale experiment, planning a cable-yarded clearcut harvest in the North Fork watershed. This operation



Stream gage and sediment sampling station in a tributary of North Fork Caspar Creek.

too produced a pulse of sediment and higher peak flows, but the sediment input was not as extreme as it had been in the South Fork. The cable yarding was much lighter on the land because it required fewer roads, and skid trails were constructed only in the few low-gradient areas that were yarded with tractors.

The simple conclusion—and a correct one—would be that logging with bulldozers in such steep, wet country is hard on the environment. And indeed, the California Forest Practice Act, passed in the early 1970s, sets forth forest-practice rules that, among other things, restrict where bulldozers can operate (not through a stream, for instance), limit the size of a logging operation, and require that trees be left along streams to protect the channel and its riparian environment.

Caspar Creek scientists can't claim credit for the whole forest practice law, says Tom Lisle, research hydrologist and program leader at



Caspar Creek, “but our work has helped make and refine the rules.” Thanks in part to Caspar Creek research, the days of unregulated logging are forever past. And that, says Lisle, is the beauty of hard data: “You can always deny there is an effect, until somebody actually measures it.”

Yet the Caspar Creek story does not end here. In the early 1990s, the sediment levels in the South Fork—thought to have recovered from the logging—started creeping higher. Lisle and Keppeler attribute this to the gradual failure of roads and culverts constructed during the logging. This hypothesis is in keeping with other findings on logging and roads in steep, moist coastal forests.

“The point,” says Liz Keppeler, “is that the effects go on and on.” Indeed, she notes, the watershed was surely greatly altered by the original, turn-of-the-century old-growth logging, although it is impossible to know how much because there are no baseline pre-logging data.

“But if we’d walked away from the forest in 1985 after measuring the effects of the South Fork selection cuts,” says Keppeler, “we would have a very different story from what we have now. This underscores the value of these long-term experiments, this long-term data set. If we walk away from here tomorrow, we will never know what long-term effects we failed to discover.”



The California Division of Forestry and Forest Service have worked together to maintain a continuous record of stream flow and sediment transport in Caspar Creek since 1962.

Tracing the Effects of Nitrogen

Fernow Experimental Forest lies squarely in the path of windborne air pollution from the Ohio Valley. It's not hard to understand why scientists there have a longstanding interest in acid rain. Recently, acid-rain research at Fernow has moved from the greenhouse level to encompass entire watersheds. It is yielding new findings about nitrogen, one of the chief culprits in acid rain.

For decades, acid rain—the common name for the deposition of air pollution containing sulfur, nitrogen, and other acidifying agents—has brought stress and damage to forests all along the eastern seaboard. Among the hardest hit have been those of the Allegheny Mountains of West Virginia, whose diverse and high-value forests collect smokestack emissions and auto exhaust from Pittsburgh and other heavily populated industrial areas to the west.

Long-term research at Fernow and other experimental forests (notably Hubbard Brook in New Hampshire) supported amendments to the 1970 Clean Air Act mandating cars that burn fuel more efficiently and cleanly and reductions in sulfur emissions from factory smokestacks. These laws are mostly concerned with sulfur, the main damaging agent in acid rain. But no clean-air legislation has yet addressed nitrogen, a common pollutant that comes from car exhaust, fossil-fueled factories, and agricultural fertilizers.

“I grew up in Indiana,” says Mary Beth Adams, forester and soil scientist at Fernow, “and one of the smells of spring was ammonia [a nitrogen compound]. The farmers would apply it to their fields, and it would volatilize and escape and come down later somewhere else.”

Nitrogen is, of course, necessary for life on earth. It is the most abundant component of air and an essential nutrient for plants. But too much can disrupt the workings of streams, lakes, and wetlands. Adams and her colleagues are looking into nitrogen's effects on upland plant communities, including forests. They want to know whether excess nitrogen is causing hard-to-detect but potentially serious long-term problems.

Excess nitrogen lowers the pH in soils, making them more acidic. Along with sulfur, it can rob the soil of essential nutrients, particularly calcium and magnesium. In some plant communities, this alteration of soil chemistry leads to a host of destabilizing effects: reduced soil fertility, changes in plant and wildlife communities, increased susceptibility to invasive exotic plants, and in some tree species, increased susceptibility to wood-attacking insects.



Workshops on the Fernow.

“For reasons we don't fully understand,” says Adams, “invasive species seem to be more efficient at using nitrogen than native plants.” The nitrogen may be boosting the invaders' growth and making them more competitive. Forest trees can absorb some extra nitrogen, but it seems to make them more attractive to insects and perhaps to browsing deer, too.

If more nitrogen enters a watershed than the trees and other plants can absorb, it runs off into streams, contaminating downstream drinking water with nitrate and causing algal blooms that deplete dissolved oxygen. Or it vaporizes into the air and becomes a greenhouse gas.

Adams and her colleagues at Fernow are studying the effects of introduced nitrogen, using watersheds of approximately 40 hectares (100 acres). They aerially apply ammonium sulfate fertilizer at double the rate that nitrogen and sulfur are found in rainfall, and then measure how the nitrogen makes its way through the system.

Because the watersheds are equipped with gauges to measure precipitation and streamflow, “we know what's coming in and what's going out,” Adams says. The scientists calculate how much nitrogen remains in the watershed and measure where it goes—how much to the soil, how much to the plants, how much to the stream environment. “We're mainly looking at the flow of nutrients over time,” says Adams. “And we measure repeatedly, so we get an idea of the trends.”



The Fernow's watershed acidification study is one of only two in the United States. "The reason this kind of work is rare," says Adams, "is that it's hard to find watersheds that can be dedicated to long-term manipulative research, such as those we have here."

Not much is yet known about how excess nitrogen might affect the animal life in the Fernow watersheds, but preliminary work on salamanders offers a clue. Researchers are looking into the stomachs of salamanders to see what they're eating. They've found more ants in the stomachs of salamanders in the nitrogen-dosed watershed than in those from salamanders in untreated watersheds.

Ants are a low-quality food for salamanders because their crusty carapaces make them hard to digest. Could the nitrogen have altered the insect community in a way that affected the salamanders' food supply? The nitrogen treatment made the environment more acidic, and salamanders do not thrive in high-acid environments. The degree to which the nitrogen is responsible for difference in the salamanders' diet is not yet documented, says Adams. "But it's an intriguing idea that we'll follow up on."

So far, the effects of excess nitrogen are most noticeable at the smaller scale: changes in water chemistry, soil nutrients, fungi, and some insects. The forest as a whole has not changed perceptibly. "The trees don't seem to care about the nitrogen," says Adams. "They're still growing well; there are no major signs of decline, no holes in the tree canopy, no trees falling over dead."

In fact, only a few incidents of damage to forests from acid deposition in rain are well documented: high-elevation red spruce in the northern Appalachians and Adirondacks, pine in the Los Angeles basin, and sugar maple in Quebec and a few areas in northwestern Pennsylvania.

This may be a testament to the resiliency of forest ecosystems. But in forests, as in humans, chronic, low-level stress can have severe consequences later on. The Fernow scientists are trying to determine whether nitrogen poses that kind of stress to the Allegheny's forests. If it does, "we don't know what the tipping point might be," says Adams, "so continued vigilance is important."



Entrance to the Fernow Experimental Forest on an autumn day.

Trial by Fire

When Martin Ritchie and his colleagues at Blacks Mountain Experimental Forest installed a research project in 1996, they were hoping to better understand the role that stand structure and fire play in the interior ponderosa pine forests type. They also hoped to gain insight into the use of fire and thinning to make stands more resilient to fire and other disturbances.

They didn't count on getting results quite so soon, but wildfires happen on their own schedule. A fire that swept down from nearby Blacks Mountain in the dry autumn of 2002 gave the experiment a rigorous real-world test.

The fire roared through the crowns of the untreated parts of the forest, killing all the vegetation in its path. But when it reached plots that had been thinned, it dropped to the ground immediately. In plots where researchers had followed the thinning with prescribed burning, the fire was halted even more dramatically—in one instance expiring before it reached a firebreak.

The Cone Fire burned about 600 hectares (about 1,500 acres) of Blacks Mountain Experimental Forest, about one-sixth of the total area, including 3 of the 12 treatment units. Fire behavior experts estimated that if none of the forest had been treated, the fire might have burned closer to 3,200 hectares (8,000 acres). “So we lost some of our treatments,” says project leader Ritchie, “but we learned some interesting things.”

Blacks Mountain Experimental Forest lies in a gently rolling basin northeast of Mount Lassen at an elevation of about 1,645 meters (5,400 feet). The forests are dominated by ponderosa and Jeffrey pine, intermixed at higher elevations with white fir and incense-cedar. The lower-lying areas have an understory of bitterbrush, sagebrush, and grass. It is a dry landscape, receiving a little over 460 mm (18 inches) of precipitation yearly, most of it as snow between October and May.

Studies on commercial logging of ponderosa pine began at Blacks Mountain in the mid-1930s. In 1933 and 1934, after it received its official research designation, the whole forest was inventoried and each tree larger than 100 mm (4 inches) in diameter was mapped, giving later researchers an invaluable baseline for comparison.

Even after the early logging studies, quite a bit of old-growth ponderosa pine remains on the forest. Recently the research at Blacks Mountain has focused on fire, both wild and prescribed. Scientists are particularly interested in the ways in which wildfire has shaped this forest over time, and also possible methods for using fire as a tool to reduce wildfire risk in both managed and reserved forests.



Prescribed fire in an unthinned research area at Blacks Mountain Experimental Forest.

Before European-American settlement, ponderosa pine forests of the interior West tended to experience frequent wildfires, although the pattern of frequency and severity varied widely from place to place. From evidence at Blacks Mountain, including rings from living and dead trees (which can reveal not only the year but the season a fire occurred), fire ecologist Carl Skinner and his colleagues are developing the most comprehensive picture yet of early fire patterns.

“We’ve detected evidence of fire on 70% of the plots across Blacks Mountain every 14 years,” says Skinner. “We’ve also looked at scarring of the trees in sequential fires, and we’ve found that you rarely get scarring of the same tree in successive fires.” This suggests a pattern of frequent, extensive fires that left a mosaic of burned and unburned patches across a wide landscape.

Because the fires burned so widely, says Skinner, the summer air was likely full of smoke. “Today’s visitors wouldn’t appreciate the vistas,” he says with a smile. “I tell people that that’s what pristine air was like back then.”

The fire pattern is different today, of course, because fires have been systematically excluded from most forested areas for over a century. Until the 2002 Cone Fire, Blacks Mountain had experienced no fire at all for 70 years. Its forests have responded by packing more vegetation into their understory—in particular, young ponderosa pine at lower elevations and white fir higher up, which get a toehold in the absence of fire. The densely packed young trees grow to compete with the older, dominant pines for scarce water.

The result, says Martin Ritchie, is that “the old-growth component in these stands is falling apart.” The large, old pines are dying, and the younger ones can’t grow fast enough to replace them. Left to itself, the forest will not



recover the character that most people associate with old-growth pine forests: the stately, golden-sided pines reigning over an open, parklike understory.

“There is a thought among some people that if you just stand back these forests will recover on their own,” says Ritchie. “But they will never recover in the absence of fire. They’ll just be dense stands of smaller ponderosa pine and fir, until some catastrophic event, resulting from fire or bark beetles, sets them back to the beginning of the cycle.”

Or unless human management—thinning or burning or both—can effectively mimic natural fire. In the 1996 thinning and burning experiment, researchers created two different forest structures on plots within the old forest. In one treatment, called “Hi-D” (high-diversity), the areas within the drip lines of mature trees were cleared and the rest of the forest was thinned, leaving snags and some dense clumps of smaller live trees. Overall, more biomass was left standing in this treatment, which was similar to a non-commercial thinning that might be done to enhance ecosystem values and reduce ladder fuels.

In the “Lo-D” (low-diversity) treatment, all the mature trees were logged and much of the understory was thinned heavily, leaving a middle canopy layer of younger pine and fir. Overall, less biomass was left behind in this treatment, which was similar to an overstory removal. Half the plots in each structure were treated with prescribed fire after the thinning, to remove even more potential fuel.

The research team at Blacks Mountain is evaluating the ongoing effects of the two treatments, in both the areas hit by the Cone Fire and the areas spared. Among the preliminary findings: the low-diversity treatment with fire seems to be the most effective in making the forest wildfire-resilient. Nearly all the trees in the Lo-D plots survived where prescribed fire was used before the wildfire. But even the Lo-D plots that had not had prescribed fire fared better in the wildfire than the untreated plots. The old-growth trees in the Hi-D treatment area generally fared well, although a few along the edge were weakened by the wildfire and died over the next couple of years from scorch or attacks by bark beetles.

More importantly for the future, the thinning and burning treatments seem to be jump-starting the growth of the pines. In the Lo-D treatments, says Ritchie, researchers expected to see more growth out of the individual trees but less out of the stand as a whole, because so many of the smaller trees had been thinned out. “But not only was tree growth higher, stand-level growth was higher.”

Even the older trees in the Hi-D plots have responded with greater growth. “We’ve wondered if it was too late to treat these older stands for maintaining high structural diversity,” Ritchie says. “The answer we found is, no, it’s not too late. At least in the short term, we’ve maintained the health and vitality of these old-growth stands by thinning. It will be interesting to see what happens in the long haul, but for now it seems to be working.”



High-diversity treatment unit 10 years after thinning at Blacks Mountain Experimental Forest.

Changing Flows from Forested Watersheds

In the far-distant past, when wildfires visited the rugged ridges and plateaus of Tenderfoot Creek Experimental Forest, they tended to burn extensively. In recent decades, however, fires that have come have been more contained, burning less of the landscape. This shift in wildfire patterns has produced a cascade of effects, altering the age and composition of the forests and potentially changing the amount and timing of the water that flows into the rivers and reservoirs below.

Designated in 1961 as a hydrologic laboratory, Tenderfoot Creek EF occupies 3,726 hectares (about 9,200 acres) of forests, wet meadows, and drier grasslands in the Little Belt Mountains of north-central Montana, just east of the Continental Divide. Its dense stands of lodgepole pine and pine/Engelmann spruce are typical of about 6 million hectares (almost 15 million acres) of fire-influenced mid- to high-elevation forests across the Rockies.

Mountain forests like these are important for human communities downstream because they collect water as snow and disburse it in the spring for drinking, hydroelectric power, irrigation, and recreation. Watersheds on the dry east side, such as the Tenderfoot Creek EF, are particularly worthy of study because they are greatly influenced by year-to-year variability in precipitation. Experimental Forest manager Ward McCaughey and his colleagues are studying precipitation and runoff patterns, trying to quantify how water from snow makes its way into the ground through a forest community that is changing in response to changing fire patterns.

The higher reaches of the forest at the Tenderfoot Creek EF are dominated by stands of pure lodgepole pine, with a few stands of mixed pine, fir, and spruce. This forest is the very definition of “doghair”—tall, skinny trees in crowded stands with dead boles fallen every which way, like jackstraws. The forest floor is thickly carpeted with grouse whortleberry, a huckleberry relative. Spread across the lower slopes of Tenderfoot Creek are broad “parks,” or meadows, with ribbons of aspen nestling in their moist creases.

The slenderness of the standing pines—they are 30–36 cm (12–14 inches) in diameter—can deceive a person trying to guess their age, McCaughey says. Unlike ponderosa pines, which are thinned to open stands by frequent, low-intensity fires, lodgepole pine typically grows from adolescence to old age as a cohort. “This type of forest is generally shaped by low-frequency, high-severity stand-replacement fire,” says McCaughey. “These stands can



Gail Wells (author) standing next to entrance sign for the Tenderfoot in early June 2008. Snow can occur in any month of the year in most high-elevation, subalpine forests of the Northern Rockies.

get to be 200 years old, if another fire doesn’t come along first, although we are finding that occasional low-intensity fires are creating some two-aged stands.”

The oldest stands on the forest date from a big fire in 1580, which burned more than half the area now falling within Tenderfoot Creek’s boundaries. The last fire of any size was in 1873, burning more than a third of the experimental forest. By the beginning of the 20th century, these big fires had ceased. A 1902 fire burned about 6% of the forest, and three subsequent fires burned less than 1% each.

“So we’re far outside the historical range of fire frequency and extent,” says McCaughey. As a result, the forest has grown older, and there are fewer open or early-successional stands. To find out how these changes in forest composition and canopy coverage might be affecting runoff, McCaughey and his colleagues started with nearly 20 years of hydrological data collected at Tenderfoot Creek, along with 50 years of measurements of nearby streams.

Using data from several Montana watersheds, McCaughey and his team estimated the amount of runoff that would be produced by a given forested watershed if the land were bare. Then they analyzed 5-year snow and rainfall data from nearby weather stations and SNOTEL (snow telemetry) sites. The SNOTEL system is a federally operated snow-measuring network with installations throughout the United States, including two at Tenderfoot Creek.



The researchers correlated the precipitation data with measurements of runoff from the Tenderfoot Creek drainage. Then they compared the accumulation of snow in open areas of the forest with that in closed-canopy areas.

They found that most of the snow that fell directly on the ground in the open areas became part of the watershed's runoff when it melted. In contrast, a substantial fraction of the snow that fell on the trees in the closed areas either evaporated or was sublimated (converted from a solid to a gaseous state without passing through the liquid phase) before it reached the ground.

In other words, bare areas collected more water from the snow than did forested areas. This was not too surprising, but in addition, the researchers found that the thickness of the forest canopy makes a difference in how much snow is intercepted and kept from melting into groundwater. In the thickest-canopied stands, about one-fourth of the water in the snow never reached the ground as liquid water.

The researchers refined their results by calculating the snow-water equivalent (SWE, meaning how much water is contained in a given amount of snow) for a range of forest vegetation types and cover densities. Then they categorized the stands according to how old they were, based on known fire history.

They observed that, after a lodgepole stand passes middle age, mortality tends to increase, and shade-tolerant spruce and fir begin to invade the open gaps in the stand. Even though lodgepole pine is no longer the dominant forest canopy, thick spruce and fir crowns begin to hold large amounts of snow, letting less water reach the forest floor.

Implications for management are still being refined, says McCaughey. If the objective is increased runoff, the older, climax-forest stands, such as those that result from less-extensive fires, will keep water production at a minimum, while a younger forest, whether created by natural fire or management, is likely to have more open or early-successional areas where the water can get into the ground.

The hydrological work at Tenderfoot Creek promises to help managers understand not only how runoff is affected by natural forest dynamics, but how different management treatments are likely to influence the amount of runoff in a particular watershed. It will also give managers a way to judge the effects on water yield as forest composition changes with a changing climate.



The majority of forest communities on the Tenderfoot Creek Experimental Forest are pure stands of lodgepole pine. Sparse and dense understories and overstories of subalpine fir and Englemann spruce can be found in a number of smaller stands scattered across the Experimental Forest.

Old Research Sheds Light on New Questions

Situated as it is in the sparsely populated Great Basin, the Desert Experimental Range (or DER) does not register very high on the public radar screen. “For a lot of folks it’s the Great Empty Quarter,” says Stan Kitchen. “Most people don’t pay it much attention.”

Kitchen is a research botanist and manager of the DER, located 260 km (160 miles) southwest of Provo, Utah. Despite its low public profile, the DER is a significant spot on the map for range ecologists, being a place where past ecological research is paying off in future-focused science. Data from long-established grazing studies are helping scientists come to grips with two of today’s pressing challenges: invasive weeds and climate change.

Composed of 22,500 hectares (about 55,600 acres) of mostly treeless salt-desert shrubland, the DER is the largest of all the Forest Service’s experimental forests and ranges. Its sparse vegetation and minimal precipitation make it typical of an ecosystem that is widespread across the vast Great Basin, an internally drained region covering about 55 million hectares (135 million acres) of the intermountain West.

More than half the land in the Great Basin is administered by the USDI Bureau of Land Management, and most of that is divided into grazing allotments for domestic sheep and cattle. Grazing has been a dominant land use since European-American settlers arrived in the mid-19th century. Historically, ranchers paid little attention to management or protection of the resource, and by the early 20th century the range had lost much of its ecosystem function and its capacity to support livestock.

The DER was set aside in 1933 as a place to investigate the economic and ecological impacts of grazing. In 1934 and 1935, the first researchers established 20 paddocks of 100–130 hectares (240–320 acres) each, of which 16 had two 4,000-m² (1-acre) fenced “exclosures,” or control areas where the animals couldn’t graze. Grazing treatments in these paddocks have been used to test the long-term effects of various combinations of grazing intensity and season.

Changes in vegetation are still being monitored today on permanent plots in these paddocks and their associated exclosures. “They’ve given us a

long-term look at plant succession in response to grazing,” says Kitchen, “and also a look at year-to-year variations in response to climate.”

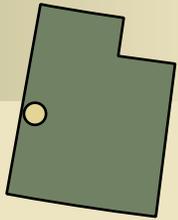
A key discovery at the DER was that, from the standpoint of environmental impact, season of use matters more than grazing intensity. “You can graze at a low to moderate level without significant impact if grazing occurs during the cold part of the year, when the plants are dormant,” Kitchen says. “That’s because the livestock are not eating the growing points on the plants, and when [the plants] break dormancy, there’s moisture in the soil, and they are able to recover.” In contrast, when the animals overgraze in the spring, the most important period for active plant growth, plants are damaged and recovery is slow.

Thanks to these findings and others, it became possible to manage grazing to minimize damage and allow the recovery of degraded landscapes. Management practices that emerged from this work call for restricting most grazing to winter months and for imposing rest periods after spring grazing. “The vegetation can be grazed in the spring,” says Kitchen, “but you should do it only every third or fourth year.”

Another management recommendation developed at the DER was that ranchers should haul water to the animals and move watering locations frequently, to distribute the impacts of grazing and limit soil erosion caused by herds moving between fixed watering locations and areas of unused forage. Frequently moving watering stations not only mitigates the environmental impact of grazing, but also increases ranchers’ profits, because animals that travel less gain weight faster.

For many years DER researchers held regular field days to show local ranchers and land managers how to apply the results of their studies. “Over time these practices were learned and incorporated pretty successfully,” says Kitchen. “If you spend any time on BLM lands like those of the DER, you can find allotments that follow practices recommended by the Experimental Range, and they’re in pretty good condition. Unfortunately, you can still find allotments that ignore the recommendations, and it shows.”

Eventually demand for on-site demonstrations dwindled, and the regular field days ceased. “That too is a success story,” says Kitchen, “because it meant the techniques developed at the DER were becoming widely known



and more commonly practiced. The fact that many of these concepts seem obvious today attests to the strong impact of the work.” Kitchen still conducts tours for visiting scientists, ranchers, university students, and government officials.

The headquarters facility of the DER was closed down between 1984 and 1992 because of budget cuts. (Quite a few of the experimental forests have faced shutdowns or cutbacks at some point in their histories.) “The Forest Service offered to transfer the land to the BLM, but apparently the BLM was not interested,” Kitchen says. Then in 1992, responding to growing university and agency demand, “and recognizing that there were a lot of questions that still needed answers,” the Forest Service reopened the headquarters facility and recommitted to a full research program.

Kitchen joined the DER at that time. Today’s research is focused on mechanisms of ecosystem stability in response to various sources of disturbance. The goal is to learn how the whole ecosystem responds to the combined effects of invasive weeds and climate change in the presence of livestock grazing.

“Ultimately, we’re interested in looking at how resilient this community is to climate change,” Kitchen says. The salt-desert-shrubland ecosystem is a good place to study that question, because it is a relatively simple ecosystem that can function as a model for more complex systems.

The importance of DER was affirmed in 1976 when it was designated a Biosphere Reserve by UNESCO’s Man and the Biosphere program. It is the only reserve of its type in the western hemisphere.



Symbolic of the wealth of knowledge generated from monitoring cold deserts, the Headquarters for the Desert Experimental Range is the “pot of gold” at the end of the rainbow.

A Giant Outdoor Hydrologic Lab

A visitor to the San Dimas Experimental Forest might be forgiven for wondering where the trees are. It's not that San Dimas doesn't have trees; the native chaparral that furs the canyonsides has a lot of scrub oak—technically a tree—amid chamise, ceanothus, and toyon. Moister riparian grottos support laurel, sycamore, and alder. And clinging to the edges of roads are a few specimens of incense-cedar and Coulter pine, exotics brought in by early foresters.

Unlike most other experimental forests, San Dimas was not established to support the commercial management of timber. Instead, it is a giant outdoor hydrologic laboratory where scientists study how water circulates through the arid, shrubby landscape, how extreme rainfall and runoff events shape the land from ridgetop to valley floor, and how wildfires affect the system's hydrology and hasten erosion.

When San Dimas was established in 1933, the pressing research question was how to squeeze more water out of the mountain ecosystem. Leaders in the rapidly developing Los Angeles basin below wanted more water for drinking and irrigating crops.

One important early study at San Dimas yielded a rough baseline of how much water was being consumed by the various plant communities. With the help of inmate laborers, researchers sank 26 large concrete containers into the hillside at the research station at Tanbark Flats. They planted each of these lysimeters, as they are called, with different grasses, shrubs, and trees. Special plumbing made it possible to measure the water coming in and going out.

Although a flawed design made precise measurements impossible, scientists found that, in general, trees and shrubs used water “extravagantly” (in the words of a later report), while grass “saved water if kept clear of weeds.”

In the decades that followed, researchers experimented with a variety of methods for getting rid of the woody vegetation and increasing the grass. These trials involved herbicides, defoliant gases, bulldozers, and other tools that today's researchers might regard as heavy-handed. Results were mostly unsuccessful—it turned out that extracting more water from these mountains proved impractical, costly, environmentally damaging, or all three.

Nevertheless, these studies and others have yielded a wealth of long-term data that are helping to answer today's important questions, such as what



In the foreground are unburned chaparral and converted grass watersheds in the San Dimas Experimental Forest. In the background is 3,050-meter (10,000-foot) Mt. Baldy, highest peak in the San Gabriel Mountains.

people can and cannot do about landslides, floods, and wildfires that characterize the restless ecosystem of the San Gabriel Mountains.

“We have upland areas that burn frequently and with great enthusiasm,” says Pete Wohlgenuth, research hydrologist and program manager at San Dimas. “We have lowland areas filled with people and property and infrastructure. Every time it burns, big erosion events happen. Part of my job is to try to understand these events for planning and risk assessment. And the other part is to determine whether we can do anything to offset some of the negative consequences in a cost-effective, environmentally sensitive way.”

The geologically active San Gabriel Mountains (along with neighboring mountains), are being upthrust as two of the Earth's crustal plates grind against each other. The mountains are rising faster than erosion is wearing them down, and over the past few million years, gravity and running water have been sloughing soil and rocks down into the valleys below.

The Los Angeles coastal plain owes its existence to fires and debris slides, says Wohlgenuth: “If we didn't have these processes, we would have a lot more ocean.” A pulse of erosion is typically triggered by a wildfire, especially if the fire season is followed by a wet winter.

Wildfire has struck the San Dimas on an average of every 40 years since its establishment in 1933 (there is evidence that the presettlement fire interval was longer). The largest and most intense of these fires occurred in 1960, when “the whole forest burned to the ground,” says Wohlgenuth.

The bare hills left by the 1960 fire seemed to reinforce the wisdom of converting the landscape into something tamer and more tractable. Between 1958 and the mid-1960s, researchers used herbicides and bulldozers on the chaparral in an attempt to “type-convert” the thirsty shrub community to grass. The theory was that the quick-growing grass would stabilize the hillside better



than chaparral. As it turned out, it doesn't—steepness of slope and intensity of rainfall make more of a difference in whether a slide will occur than the type of vegetation growing on the ground.

Other erosion-control experiments from that era included building concrete check dams along tributary streams, digging wide contour terraces across the slope with a bulldozer, and planting barley in horizontal strips.

Results of these trials were inconclusive, says Wohlgemuth. The 1960s produced several dry years in a row followed by wetter years and culminating in the storm of the century in 1969. So it was hard to tell if the weather or the treatments made more of a difference.

In the 1970s, many of the water-flow monitoring stations at the San Dimas were mothballed (“under the illusion that we’d learned all we could from that study,” Wohlgemuth says), and ultimately the ideal of large-scale manipulation of the landscape fell out of favor for both environmental and practical reasons. “Most people would not use those treatments today. But that’s why we have experimental forests—so you can try this outlandish stuff and see if it works.”

Another fire in 2002 offered an opportunity to try other ways of slowing erosion. One test concerned a chemical called polyacrylamide, which is used in agriculture as a flocculant—it binds soil particles together. The manufacturing company offered to aerially spray its product on the San Dimas as a field test. Aggregating the soil into larger particles, it was thought, would encourage water to infiltrate rather than sweep downhill and carry the soil with it.

A few years before the fire, Wohlgemuth and his colleagues had reactivated the mothballed monitoring stations. They had been keeping track of water flow for eight years by the time the 2002 fire occurred, so they were prepared to evaluate any change that occurred as a result of the chemical. A few years of measurements revealed that the spray didn't work well enough in the shallow, coarse San Gabriel soils to warrant the expense of applying it.

A more promising treatment is stream-channel barriers made of prefabricated log sections placed every 9–15 meters (30–50 feet) along a channel. “We found they worked great,” says Wohlgemuth. “They reduced erosion down at the debris basin tremendously, and eventually they'll biodegrade.”

Whether or not it has paid off in practical tools, all the research at San Dimas has yielded useful information. “Experiments like these are the only way we can learn how the natural system works,” says Wohlgemuth. “If we don't know how to understand and quantify products like water, or sediment that is poised to come down into somebody's living room, there's no way we can develop cost-effective mitigation that will still be environmentally benign.”



The 2002 Williams Fire produced floods and massive erosion on the San Dimas Experimental Forest.

The Breathing of Peatlands

Forests have been called the lungs of the planet, but peatlands—those swampy areas in northerly climates where soil is mostly organic and slow to decompose—equally deserve the title.

Peatlands occupy a huge swath of territory north of the 45th parallel in North America, Europe, and Russia. If you started in St. Cloud, Minnesota, and drew a line east across Lakes Michigan and Huron and through Ottawa, northern Vermont, and Maine, and then a line west through South Dakota and along the Wyoming-Montana border, you'd be drawing the rough southern boundary of the North American peatland zone.

Peatlands are carbon sinks, and highly efficient ones, because they pack away a disproportionately large amount of CO₂ relative to the land area they occupy. The reason they're so good at storing carbon is that their cold, waterlogged, oxygen-poor environment inhibits decomposition of the organic matter that makes up peat soil.

Thus far, the peatlands of the world have been helping to put the brakes on global warming. That may be changing, says Randy Kolka, soil scientist and team leader at the Marcell Experimental Forest, which sits squarely in the peatland zone of northern Minnesota. A warming climate could hasten the decomposition of peat, eroding the capacity of these lands to absorb CO₂ from the atmosphere. Research in Britain, says Kolka, suggests that some peatlands there have already flipped from being a carbon sink to a source—they're now releasing more than they're storing.

Kolka and his research team are measuring gases flowing into and out of the peatlands at the Marcell, trying to find out what is happening there. "We want to know three things," he says. "If [the peatland] is still storing carbon, how much is it storing? If it's become a source, how much of a source is it? If it's not a source, has its ability to sequester CO₂ lessened over time?"

Research at the Marcell, begun in 1960, historically focused on timber harvesting and its effects on water quality and quantity in upland and peatland watersheds. Scientists have also been investigating mercury, a toxic pollutant that accumulates in living matter up the food chain. These studies have produced long-term data on streamflow and water



Measuring snow amount at the Marcell Experimental Forest to help predict the spring flows resulting from snowmelt.

chemistry that have proven valuable for assessing ecosystem carbon storage and climate change. (The harvesting and mercury studies continue, and their findings have served as the scientific basis for widely used land-management policies and guidelines.)

Research on peatlands and CO₂ began in 1988, as global climate change was catching public attention. A group of scientists led by Shashi Verma, from the University of Nebraska, and Sandy Verry, from the Forest Service, used an array of high-tech instrumentation called an eddy covariance system to monitor the "carbon flux"—the amount of CO₂ flowing into and out of peatlands. "This was one of the first places on the planet where scientists were looking at how the peatlands 'breathe,' if you will," says Kolka.

Those experiments ended in the early 1990s, and for a time no more measurements were taken. Kolka and his colleagues resumed the study in 2006. In 2007 they had their first full year's worth of data. After another couple of years they'll be able to compare their data set with that of Verma and Verry, and see what has changed over two decades.

The researchers are also looking at the flux of methane, picking up where the studies left off in the early 1990s. Although less methane than CO₂ is present in the atmosphere, methane produces a stronger atmospheric greenhouse effect.

In addition, they are analyzing the Marcell's collected data on dissolved organic carbon (DOC). DOC is a measure of carbon dissolved in the water flowing out of the peatlands. It is a relatively small influence on

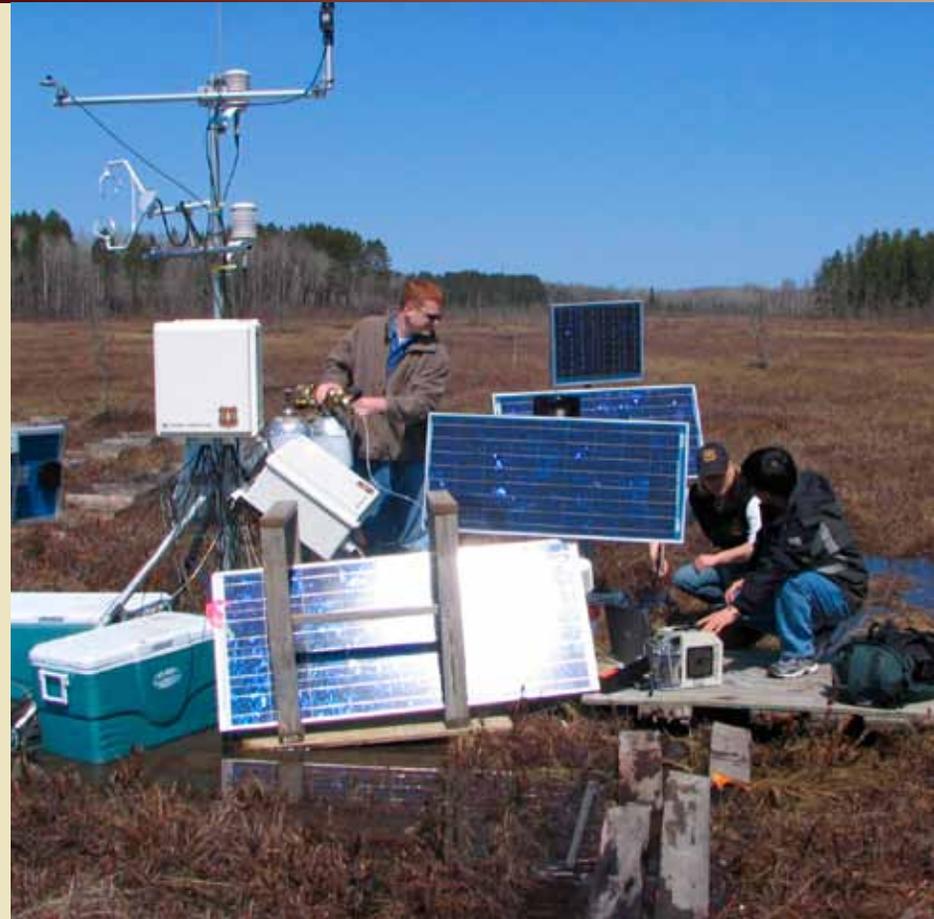


overall balance of carbon in a watershed, Kolka says, but a change in the amount over time could be a signal of a climate-change effect on carbon balance. “If the climate is warming, we would expect to see more gases coming out of the peatland, and more carbon dissolved in the water coming out,” he says. “If these levels are increasing over the past 15 years, it may indicate that climate change is affecting the peatlands.”

With the help of funding from NASA, Marcell scientists are comparing their data with those from other research sites in the Rocky Mountains and the northeastern United States, trying to get a picture of carbon flux across the landscape. The goal is to combine plot-scale measurements and extrapolate them accurately up to larger areas—states, regions, even the whole world.

Better large-scale measures of carbon flux would improve the reliability of the computer models that monitor global climate. “These models are only as good as the data going in,” says Kolka. “Our research is an attempt not only to understand carbon flux and storage at our scale, but to add to the database that allows us to measure these at larger scales.”

An important goal of research at the Marcell is to show policymakers how to utilize the land in mitigating the warming of the planet. (The average temperature at the Marcell, notes Kolka, has risen about 2°C since 1960.) Some policies that might flow from the Marcell’s findings are measures to protect peatlands from development, fire, or other disturbances. “Right now, peatlands are mitigating a warming atmosphere. If things are flipping the other way, or even if they’re becoming less of a sink than they were before, that matters a lot.”



Current eddy covariance system at the Marcell Experimental Forest measures the net exchange of carbon dioxide between the atmosphere and the peatland.

Bringing the Oak Forest Back

By the time the Forest Service took it over in 1914, the Pisgah Forest—which would later become part of the Pisgah National Forest—was in rough shape. It had once been part of the famous Biltmore Estate, where the wealthy George W. Vanderbilt had pioneered scientific forest management by employing European-trained silviculturists Gifford Pinchot and later Carl A. Schenck. Before Vanderbilt's time, the land had been worked over for 100 years by homesteading farmers and by timber companies that stripped out the best of the valuable hardwoods. The trees that remained were stunted and deformed. Furthermore, American chestnut, once a dominant tree in the East, was being decimated by the chestnut blight, an introduced fungus.

The Pisgah National Forest became the first national forest east of the Mississippi. Like many others across the nation, it was assembled from “the lands nobody wanted,” says David Loftis, research forester and former project leader at the Bent Creek Experimental Forest. “By the 1920s, virtually everything had been cut over, burned, and largely abused, with no provision made for regeneration.”

In 1925, Bent Creek Experimental Forest was set aside on the newly established Pisgah National Forest. (Its campus, near Asheville, is on the National Register of Historic Places.) The first research priority for Bent Creek was to conduct silvicultural experiments with the goal of bringing the degraded forest back to something resembling its pre-logging, pre-homesteading condition.

The forest at Bent Creek is typical of the oak-dominated forests of the low-to mid-elevation southern Appalachian Mountains—a complicated landscape, topographically and ecologically. The climate is mild and moist, and forests of many species of trees and shrubs range over the ridges and coves. The development of these forests may follow any of several successional pathways, with disturbances such as ice, wind, fire, and insects playing a poorly understood role.

Of the dozens of hardwood species, oaks are of high economic and ecological interest. They dominate the forest on dry sites and are an important component in mixed stands on moist sites. Their wood is valuable for timber, and their acorns are important food for many wildlife species.



The Buell regeneration study began in 1931 with the first clearcut created for the sole purpose of studying natural stand regeneration dynamics on the Bent Creek Experimental Forest.

Because the climate in these parts is mild, the forest vegetation was growing back just fine, says forester Julia Murphy, Bent Creek's technology transfer specialist. “The forest was regenerating but not with the same tree species that were present before the disturbances.”

An early study at Bent Creek, established in the 1930s, was a clearcutting experiment directed at naturally regenerating the forest. Clearcutting may have seemed an odd thing to try. The forest had been laid waste, after all, by a sequence of clearing, burning, and logging that had nearly denuded the landscape. And indeed, says Loftis, the timber managers on the Pisgah National Forest at the time favored selection harvesting (in which trees are harvested singly rather than in large blocks), partly because of concerns about the damaging effects of past unregulated cutting.

Before beginning the study, silviculturist Jesse Buell drew on the earlier observations of E.H. Frothingham, the first director of the Appalachian Forest Experiment Station, that heavy cutting seemed to promote better regeneration than lighter, partial cutting did. More practically, Buell had little choice: there was almost no forest left to work with. “So he inventoried the stand and then clearcut it, and started observing, measuring, and recording what happened,” says Julia Murphy. There was no need to plant seedlings because in contrast to tulip-poplar, most tree species in these forests regenerate from seedlings or saplings that exist prior to cutting, and also by sprouting from the stumps of harvested trees.



What happened was that the moist, lower slope was dominated by the light-loving tulip poplar along with a few oaks and other species, while the drier middle and upper slopes regenerated primarily to oaks. Buell and researchers who followed experimented with a variety of harvest methods, including even-aged (such as clearcut and shelterwood harvesting), uneven-aged (such as selection harvesting), and two-aged methods. They tried various levels of cutting and other management strategies to control light prior to heavier cutting in the overstory.

Findings from Bent Creek's ongoing studies show that harvest methods that remove most of or all the overstory in one or more removal cuts—in either a small lot or an entire 16-hectare (40-acre) stand—are the most appropriate for regenerating the forests of the southern Appalachians. For these methods to be effective, large seedlings or saplings of many species, including oaks, need to be present when the overstory is removed. Otherwise, light-loving species, such as tulip-poplar, will win the “race” by growing faster and overtopping other species. Therefore, managers need to control the light reaching the understory for several years in advance of overstory removal so that this regeneration of more shade-tolerant species can develop.

The research at Bent Creek took a while to get noticed, says Loftis. “But eventually people began to see that the kind of silviculture the Forest Service was practicing in the southern Appalachians was not leading to adequate regeneration.” By the mid-1950s, results from the Buell study were beginning to guide the shift toward even-aged silviculture. “That was one of [Bent Creek's] very first impacts of silvicultural research on the practice of silviculture,” Loftis says.

Like most other experimental forest research, the Buell study illustrates the value of keeping long-term studies going. It takes years to get definitive results, and what becomes common practice in one generation may be challenged in the next. The Buell plots are still being measured, and so are those in a later study, begun in the 1940s, of uneven-aged methods. The various treatments are displayed in side-by-side plots for the education of managers and other visitors. This is in keeping with Bent Creek's other key mission, demonstration and delivery of scientific results to managers and the public.



Researcher takes measurements on oak regeneration on the Bent Creek Experimental Forest.

A New Look at Old Growth

Back in the 1930s and 1940s, when many experimental forests were starting their research, old-growth forests were typically not on the agenda. The main focus was either timber management (mostly in the West) or land restoration (mostly in the East), depending on the condition of the landscape in question.

Over the decades, however, values shifted. Old-growth forest, in its variety of forest types, ages, ecosystems, and desired conditions, has become socially and scientifically important in terms other than timber. This has prompted researchers to view some of their old findings through new eyes.

For example, long-term studies at Blacks Mountain, in northern California's ponderosa pine country, initiated in the 1930s and carried forward to the present, have demonstrated that the ecological conditions in these forests are much changed from those of presettlement times, when fires typically occurred every 8 to 10 years. A new long-term study begun in the mid-1990s is shedding light on the resilience of these older-forest ecosystems and their response to management manipulation.

The study suggests that conditions common in presettlement forests—notably the big, vigorous older pine trees (between 250 and 800 years old) and the open understory—will not come back as long as fire is excluded. In fact, these forests are at considerable risk of high-severity fire because of the proliferation of understory vegetation that has come in over more than a century of fire exclusion and grazing.

However, active management, such as thinning and prescribed burning, shows promise for restoring these desirable old-growth features. These treatments, which remove understory vegetation to varying degrees, seem to be enhancing growth in the older pines at Blacks Mountain and lowering their mortality rates. Properly carried out, the practices have the added benefit of making the forest more resilient to wildfire and insect damage.

When the Coram Experimental Forest was established in western Montana in 1933, nearly all its western larch forests were old growth, typical of vast areas of pre-settlement mid- to high-elevation forestlands across the northern Rockies. Part of the Coram was set aside as a Research Natural Area (RNA) in 1937; the intent was to keep it undisturbed so it could provide baseline information. Active research on the rest of the Coram Experimental Forest began in 1948, with studies focused mainly on natural regeneration after various methods of logging, including clearcutting.

In the 1960s and 1970s, researchers at Coram began new tree-spacing studies and studies of harvesting methods other than clearcutting, testing the effects of these treatments on growth of the remaining trees and the overall stand, as well as on wildlife, soil, and water. They also started studies on old-growth dynamics within the Coram RNA. In 1976, Coram, together with Glacier and Waterton Lakes National Parks, was designated a "Crown of the Continent" Biosphere Reserve by the U.N. Man and the Biosphere program.

Scientists at the H. J. Andrews Experimental Forest in western Oregon began to look closely at old-growth forests in the 1970s, building on two decades of more conventional research on the effects of various forestry practices and harvest patterns on watersheds. Work at the Andrews Forest was thrust into the public eye in the 1990s, after the northern spotted owl was declared threatened under the Endangered Species Act. Federal land managers drew heavily on Andrews old-growth research in developing a conservation strategy for the owl, and Andrews research informed the Northwest Forest Plan of 1994, under which federal forests in the Pacific Northwest are now managed.

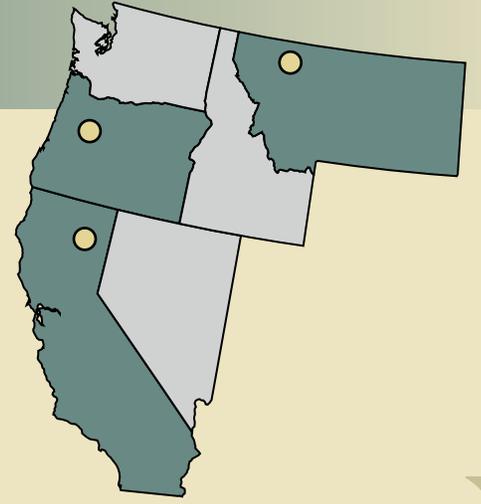
In addition, Andrews scientists have done path-breaking work on the ecological roles of dead wood, a major component of old-growth forests. Once considered waste, fit only to be hauled away and burned, dead wood is now known to be crucial in the functioning of forest and stream ecosystems. Dead wood stores carbon and keeps it out of the atmosphere; it breaks down to become fertile organic soil; it is the growing medium for many plants and essential habitat for microorganisms and larger creatures; and it is a medium for nitrogen fixation, which enhances soil productivity. Because of Andrews Forest research, ecological roles of dead wood are now widely recognized.

Thanks to the longevity of research throughout the experimental forest network, studies begun in one era can shed light on problems arising in the next. Today's research promises to prove useful in solving tomorrow's problems, which we can now hardly imagine.

Spies, T.A., Duncan, S.L. (eds). 2008. *Old Growth in a New World: a Pacific Northwest Icon Reexamined*. Island Press, Washington DC.



*Mature, interior ponderosa pine
old growth on Blacks Mountain
Experimental Forest.*



Getting The Science Out

One of the most important missions of experimental forests is to get the science out to the people who need it. “If we want an informed public,” says Mary Beth Adams, project leader at the Fernow Experimental Forest, “it’s vital to connect people with their environment and to demonstrate how various management options affect that environment.”

Fernow’s Timber and Watershed Laboratory in West Virginia is a landmark for teaching, training, and demonstration. Fernow’s scientists lead interpretive tours showcasing the forest’s half-century of research on hydrology, silviculture, and wildlife ecology. “Our audience for these show-me trips runs the whole gamut, from grade school children to college students to professional foresters to scientists from other nations,” says Adams. The Fernow is also a beautiful place to visit, and self-guided walking and driving tours are popular with tourists.

Fernow’s scientists are also reaching out to their counterparts on the other watershed-focused experimental forests, including some of those profiled in this publication: Marcell, Tenderfoot Creek, San Dimas, and H. J. Andrews, as well as Coweeta in North Carolina, Hubbard Brook in New Hampshire, and Fraser in Colorado. “When we bring our data together,” says Adams, “we can start to interpret watershed processes at a regional or even national scale and find answers to bigger questions. That’s one of the cool things about watershed science—it’s distinctive to the Forest Service. Nobody has as many long-term watershed studies as we do.”

A long-standing and popular outreach program at Kane Experimental Forest in western Pennsylvania grew out of a regeneration crisis in black cherry forests in the mid-1960s. Kane researchers launched an intensive effort to figure out why stands of black cherry, a valuable commercial species whose range is centered in western Pennsylvania, were not regrowing after harvesting.

It turned out there were two related regeneration problems: First, in this forest, seedlings needed to be well-established and abundant before the harvest. And second, deer were eating the seedlings after the disturbance (or harvest).

Excluding the deer solves most of the problem, says Susan Stout, a silviculturist and project manager in charge of the workshops. But in addition,



Bent Creek Experimental Forest provides opportunities to showcase research results.

Kane researchers developed a technique for inventorying the smaller seedlings and designing site-specific techniques for cultivating them, thereby boosting regeneration success even more.

When managers began excluding deer and using the new inventory technique, regeneration success shot up to over 90%. In the early 1970s, Kane began holding an annual week-long workshop to teach the new technique.

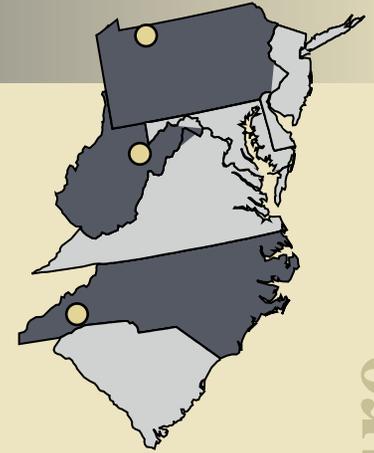
The workshop has become an institution in Pennsylvania, “something like a rite of passage,” says Stout. “When you’re hired any place in Pennsylvania as a forester, you go to a training session in your first year.” Over the years some 2,500 people have attended, many more than once—the program’s curriculum is refreshed each year as new research results become available. In recent years Kane has extended the sessions to Ohio and West Virginia.

For participants, the workshop rekindles the spark that led them to their life’s work in the first place. “We get to think about the forest again, as a whole, and in a passionate way,” says Stout. “We have a steak fry on Wednesday night, and we stand around the bonfire and talk till the wee hours of the morning. We are immersed in what we really love.”

Because of its ties to the famous Biltmore Estate, the acknowledged birthplace of scientific forestry, Bent Creek Experimental Forest has been in the spotlight right from the start. Bent Creek was on the rail line from Washington, D.C., which made it a convenient showcase of early Forest Service research, regularly toured by visiting dignitaries and scientists. “Theodore Roosevelt came here, and Gifford Pinchot, too,” says Julia Murphy, technology transfer specialist for Bent Creek.

After 83 years the visitors are still coming by car, horse, mountain bike, and on foot. Among Bent Creek's regular outreach programs is a two-week training for managers of national forests working in upland hardwood forests throughout the eastern United States. Bent Creek also conducts a one-week lecture and field training for state and private forest managers. Instructors use the demonstration forest and many active field studies within the Bent Creek Experimental Forest to teach about sustainable timber management and wildlife considerations in an upland hardwood ecosystem. Bent Creek hosts hundreds of visitors annually for individually tailored field tours of its demonstration plots. Visitors include university classes in forestry and environmental studies, research scientists, natural resource managers, private landowners, state and private foresters, middle school students, and the general public.

A rising demand for recreation on the Bent Creek Experimental Forest is both a challenge and an outreach opportunity. "We're 10 minutes away from Asheville, and we are being overrun by recreation—mountain biking, horseback riding, running—and a lot of people don't know or value what we do," says Julia Murphy, Technology Transfer Specialist. She's plunged into an interpretive program that combines friendly tips about proper recreational behavior with information about Bent Creek's science and its contribution to environmental values.



Forest Service workshops on experimental forests are popular training events for young and old alike.

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