PNW
Pacific Northwest Research Station

Science FINDINGS

issue twenty-seven / september 2000

INSIDE

"Science affects the way we think together."
Lewis Thomas

IF YOU TAKE A STAND, HOW CAN YOU MANAGE AN ECOSYSTEM?
THE COMPLEX ART OF RAISING A FOREST


Photo credit: USDA Forest Service

Desired old-growth forest conditions do not automatically occur simply by placing second-growth forests in reserve.

IN SUMMARY

Managing whole ecosystems is a concept gaining considerable acceptance among forest managers throughout the Northwest, but it does not have a clear or simple definition.

Terminology and definitions can be confusing.

Forests are complex places, formed by complex processes, and the moment we try to simplify, we are likely to damage the healthy functioning of those processes. Clearly, understanding why we are making certain management decisions can help improve eco-system management approaches.

One way—among many—to measure progress in ecosystem management is through monitoring certain small-mammal populations, such as squirrels and chipmunks, whose abundance indicates healthy function of ecosystem processes.

"So many gods,
so many creeds, So many
paths that wind and wind."
Ella Wheeler Wilcox 1855-1919

Two strategies for managing forests for multiple values have become fairly typical across the Pacific Northwest. One requires intensive management with commercial thinnings and long rotations, with a view to maximum timber production under current environmental laws. The other calls for passive management with legacy retention and long rotations, with a view to rebuilding old-growth characteristics.

The idea of rebuilding old-growth by well-planned ecosystem management has obvious appeal. Some forest plans, including the Northwest Forest Plan, assume that late-seral (old-growth) forests will develop automatically when second-growth forests are placed in reserve, particularly if they have biological legacies such as standing live and dead trees and fallen trees or logs.

But ecosystem management, Andy Carey says, must evolve. Managing for a fully functioning old-growth ecosystem, requires more than merely preserving some features of an intact ecosystem, such as a certain number of snags and logs per acre.

"In the first place, old-growth forests evolved from a unique set of conditions that cannot be recreated, so pursuing that goal doesn't even make sense. But in any case, if you manage just for structure by preserving some features, even with the best of intentions, you are managing for the symbols of the ecosystem process, but not for the effects of the process," he says. "To achieve resiliency and sustainability, managers must think and plan in terms of ecological systems, which are hierarchical and interlocking, and ecosystem processes that produce mixes of services and goods over space and time."

Simply put, we cannot, anywhere, be thinking about simple structures, a few features, one product, one spatial scale, or a short time period.

This, of course, makes things complicated.

KEY FINDINGS

- Diversity at the landscape unit, or "stand," level helps produce complexity in structure, composition, and food web pathways at multiple geographic scales. Complexity contributes to synergy—properties emerge at each higher scale that are more than the simple sum of their parts.
- The homogeneously diverse pattern at the landscape-unit scale results from the environmental condition of the site and six biotic processes: crown-class differentiation, decadence, canopy stratification, understory development, development of habitat breadth, and niche diversification. The latter two processes can occur only as a result of the other four.
- Accumulation of biomass, living and dead, is key to complexity and resiliency in forest ecosystems and landscapes. In forest ecosystems, decadence is the process most potentially affected—negatively—by narrowly focused silviculture.
- A combination of surveys, simulations, and field experiments demonstrates that commonly used strategies for forest management can have unintended consequences. For example, focus on wood production alone can simplify ecosystems; preservation of second-growth forests with biological legacies can forestall development of late-seral forests.

BROADENING THE DEFINITION OF ECOSYSTEM MANAGEMENT

Carey, a research biologist for the Pacific Northwest Research Station, is pursuing science-based alternative management pathways toward a combined result that addresses the complexity, function, and sustainability of forests and landscapes. His quest has him assessing the semantics of ecosystem management, analyzing the role of science and the type of science that can best contribute to management, meeting with and sometimes being criticized by both timber managers and environmentalists, and taking occasional heat from his own colleagues.

The 1990s have produced major changes in the Pacific Northwest. Management methods and harvest levels across land ownerships are changing, scientific concepts about ecosystems are changing, and communities are changing. Furthermore, the changes are not always synchronized, and sometimes old terminology can get in the way of new thinking.

Take the basic unit of traditional silviculture: the stand. A stand is defined as a contiguous group of trees sufficiently uniform in age-class distribution, composition, and structure, and growing on a site of sufficiently uniform quality to be a distinguishable unit. Focus: trees and uniformity.

"Terminology can frame thinking in such a way that one can't see the forest for the trees," says Andy Carey. "But what distinguishes stands from ecosystems, or stand tending from ecosystem management? It is a shift in focus, from uniformity in structure and product, toward complexity, function, and sustainability at the landscape unit."

Natural landscape units—those Carey calls homogeneously diverse—are distinguishable as units from a distance, such as can be seen in an aerial photo, but show much diversity when viewed up close, such as when walking through the forest. It is this complexity, he believes, starting at this smallest scale of management, that is the master key to the future of our forests; it helps produce complexity in structure, composition, and food webs.

Purpose of PNW Science Findings

To provide scientific information to people who make and influence decisions about managing land.

PNW Science Findings is published monthly by:

Pacific Northwest Research Station
USDA Forest Service
P.O. Box 3890
Portland, Oregon 97208
(503) 808-2137

Sherri Richardson Dodge, Editor
srichardsondodge@fs.fed.us

Carlyn Mitas, Design & layout
mitas@hevanet.com

United States Department of Agriculture

Forest Service

Check out our web site at:

http://www.fs.fed.us/pnw

MANAGING FOR PROCESSES AND SCALES

Five identifiable processes underly forest development: crown-class differentiation, in which dominant and codominant species and trees outmaneuver others for light within the canopy; decadence, both in standing and fallen trees; canopy stratification, in which treetops develop distinct layers; understory development of shrubs; and development of habitat breadth, which results from such factors as diversity in tree species and foliage height. A sixth process is niche diversification, to which all the others contribute. Niche diversification involves the development of diversity of occupations for organisms within the system, so that variety among and within communities increases.

In each part of a forest, and at each stage of development of a forest, these processes interact to produce a synergy of forest development, a set of emergent properties that could not exist without the specific sets of conditions set up by the processes that came before them, Carey says.

"As late-seral forests develop, complexes of habitat elements interact at small scales. This allows simultaneous increases in the number of species and abundance, for example, of rodent populations, despite overlap in their food, den, and space requirements." He adds that if the abundance of these animals were low relative to old growth, it would suggest that important ecosystem processes were malfunctioning, and perhaps were being mismanaged.

The challenge for genuine ecosystem management becomes that of managing a forest across multiple scales. Not just for snags and logs per acre but for suitable habitat for viable populations of birds and animals across hundreds or thousands of acres: the landscape scale. Not just for tall healthy trees in a harvest unit, but for dead ones too, and for a combination of both, along with lots of shrubs, across whole watersheds.

"The idea of seeking variability rather than uniformity within a forest is not difficult to convey to managers," says Carey. "But when it comes to describing the scales of variability, I resort to diagrams, showing circles within circles, and talking a lot about synergy." Synergy is best thought of as the "extra energy outcome" created when the total effect is greater than the sum of the individual effects.

LAND MANAGEMENT IMPLICATIONS

- To achieve resiliency and sustainability, managers must think and plan in terms of ecological systems, and ecosystem processes that produce mixes of outputs over time. It is not sufficient to think in terms of simple structures, a few species, one product, one spatial scale, or a short time period.
- The mix of goods and services to be produced must be considered, and the time frame needs to span a century, not a decade.
- Complexity, biotic integrity, and accumulation of biomass may be the keys to resiliency and ecosystem health, especially in wetter forests of the Pacific Northwest. Forest health in Western interior forests may depend on intermediate disturbances.
- New measures of ecosystem integrity developed out of complex systems are now available, as are new classifications of forest development, and their relation to silvicultural activities.

"Managers know that what I'm getting at is going to complicate their lives, but many of them also recognize instinctively that if there are benefits to be gained, they will end up having an easier time of it with the public."

It turns out that decadence may be the forest-building process potentially most affected—negatively—by silviculture focused solely on trees and wood production. A tree that begins to rot in the forest, serving an ecological purpose for wildlife while doing so, may eventually fall to the forest floor. At that point, it has filled two more ecological functions: it has created a gap in the forest canopy, thus encouraging growth of some understory species and diversity of vegetation types, and it has become a log, a potential home to a whole new community of forest dwellers.

If the surrounding forest had been removed previously, though, that decaying tree could not have fulfilled any of these functions. Or if the tree had simply fallen before rotting, it would never have become a den site for martens, bears, or chipmunks, for example.

"Other forest development processes can be accelerated or truncated by narrowly focused silviculture; decadence can only be truncated," Carey says. "It turns out to be one of the most challenging processes for which to manage, and also, to my surprise, one of the least understood. Although most managers have understood the role of snags for some time, the role of decay in both standing and fallen trees is not yet widely known. We need to correct that." Accumulation of biomass, both living and dead, is a key to complexity and resiliency in forest ecosystems and landscapes.

But there is more than a problem with understanding and managing for decadence. The theory about forest stages and emergent properties, or synergy, is difficult to prove.

AN IMPROVED MODEL OF FOREST DEVELOPMENT FOR MANAGED STANDS

Stages of forest development in managed forest:

• Ecosystem reinitiation	• Understory reinitiation
• Canopy closure	• Canopy stratification
• Competitive exclusion	• Niche diversification
• Biomass accumulation	• Natural old-growth forests

*Each of these can be either **simple** or **complex** in structure.*

SQUIRRELS AS INDICATORS

The evidence which Carey posits his theory of how to manage for ecosystem function across large landscapes is not derived at by the conventional scientific method. In the absence of planned experiments to test hypotheses, he has sought—on real landscapes with real data—to demonstrate connections by combining cross-sectional surveys of landscapes. These rely heavily on establishing correlations and quasi-experiments in which examples of particular landscape outcomes are tested against each other. He also cross-checks his theories with computer simulations of future outcomes.

"This approach is subject to criticism every step of the way, and subject to all kinds of biases," he admits, "but it's the best we've got, and it may be the best we're going to get. Think about it: at Fort Lewis (Washington), we've set up a 20-year experiment to test two or three simple hypotheses, which will give us just a few answers, and at the end, we won't really know all that we've failed to find out." In an ideal world, he says, we would have unlimited funding, data, land, and time to get all the answers.

Meanwhile, there are squirrel populations to observe in the effort to produce the best evidence available. In several locations, Carey and others have measured squirrel and chipmunk populations to test their abundance through various stages of forest development under different management (and no management) strategies. Why these species?

"Squirrels tell the most symbolic story," says Carey. "People quickly understand the truffle-eaten-by-flying squirrel-eaten-by-spotted owl story. From there, it's an easy step to expand the concepts to fungi and fruits in a healthy forest, nuts and seeds spread by squirrels and their like, who then become food for various predators."

The point is, populations of these and other tree-dwelling rodents tend to become more abundant as a forest progresses into the late-seral/old-growth stage: their abundance is an emergent property of this stage of development. Measuring population abundance under various strategies is a fairly telling test of whether the particular management strategy is nurturing the ecosystem processes that support biodiversity.

SQUIRRELS SUGGEST ANOTHER PATHWAY

The retrospective surveys reviewed both legacy retention with passive management, and intensive management for timber with commercial thinnings, the two predominant forest management strategies across the Pacific Northwest. According to Carey, neither strategy produced the increased abundance of the tree-dwelling rodents that is typical of old-growth forests.

What he suggests as an alternative is following one of various biodiversity conservation pathways, which means entering the forest at regular intervals (such as 30, 50, 70 years, etc.) for variable thinnings, and at each entry posing specific decision questions.

"The first and overriding question is What are your management intentions? From there radiates all that follows, so when you first harvest, you can answer the question, How many and what kinds of things do you want to leave and why? The same after commercial thinning." The questioning ideally continues, he says, for each of up to three commercial thinnings: What is the pattern needed with this ecosystem or landscape unit to get the benefits I want in the future?

Photo credit: USDA Forest Service

The flying squirrel can be an indicator of ecosystem function. Flying squirrel populations increase as forest conditions more closely match those of old-growth forest conditions.

Overall, the strategy of conserving biodiversity suggests maintaining a managed but dynamic mosaic that meets diverse human needs on a time schedule that seems reasonable given what we know about forest development.

"The irony is, we're recommending far more management than is normally encountered under timber production approaches that are typically designed around maximizing net present value. It actually doesn't take many visits to the forest to harvest the timber off and replant, and then do one precommercial thinning, wait, and harvest again," he explains. "What we are proposing demands a lot of time in the forest."

WRITER'S PROFILE

Sally Duncan is a science communications planner and writer specializing in forest resource issues. She lives in Corvallis, Oregon.

NEW INDICES FOR ECOSYSTEM FUNCTION

No one single measure, such as squirrel abundance, gives the full story of the state of ecosystem function. It can't, Carey says. He and his research teams propose to add measures of soil food webs, diversity of fungi and their fruiting activity, composition and diversity of vascular plants, and diversity and abundance of forest-floor communities of small mammals. Other measures such as production of deer and elk, net present value (of timber), and sustainability of revenues can add further information.

Requirements of the Northwest Forest Plan for survey and management of old-growth associated species assume that hundreds of different species will be managed for, often by keeping out of the forest, Carey points out. The new measures he proposes appeal to both timber managers and environmentalists for two specific reasons. First, they are not limitless and unwieldy. And second, they encourage intentional management to improve general sustainability—which means being in the forest—rather than staying away because a listed or sensitive species might be present.

"What we're really trying to do is capture different ways of looking at ecosystem function," he explains. "All of these items being measured are related to maintaining diversity and ultimately ecological integrity." And when managers are taking human values into account at the same time, it is less likely that resulting decisions will end up in conflict or in court. Carey goes so far as to suggest that the conflicts between timber and wildlife, between commodities and intangible values, are artificial and can be avoided by taking intentional management pathways.

THE SCIENCE-TO-MANAGEMENT CHALLENGE

What comes up for question out of Carey's current work, along with the validity of the science, is the exasperating—for the public—question of which scientist to believe.

For he is not alone in suggesting new ways of measuring ecosystem function, in posing improvements to various management systems and presenting the scientific basis of his arguments.

At a colloquium of managers he convened in 1997 in Forks, Washington, Carey and others sought feedback from on-the-ground managers on the practicality of implementing ecosystem management.

"There seems to be considerable variability in use of ecological terms and concepts across agencies, institutions, and disciplines," he says. "Standardized definitions do not exist, and many practitioners expressed disdain at fuzzy or faddish terminology and concepts."

As well as new measures of ecosystem integrity, Carey and others have developed new classifications of stages of forest development and related them to silvicultural activities, to help managers make decisions about maintaining complexity. What is perhaps unique to his work is this heavy emphasis on complexity, both of forest ecosystems, and the decision pathways needed to manage them.

He also has run the numbers on the economics of his recommended approach and found that they can return a substantial increase in sustainable revenues and employment through time. "What happens is you're using more of the productive capacity of the landscape, and you're producing a more mature and diverse set of forest products," he explains.

With or without new measures and classifications, public and private organizations need to recognize that scientific paradigms, concepts, and terminology are not immutable, Carey emphasizes. Poorly developed terms and concepts may impede organizational learning. And yet, the sometimes tumultuous changes of the last decade have lent themselves to fuzziness by the sheer speed of their implementation. What is most important, he says, is that we do not, by any management approach, start closing off our options.

"A win-win approach is possible, by keeping complexity of ecosystems clear in our minds, and not getting bogged down in the lose-lose debate over cutting old growth, for example," he says. "A concept of general sustainability seems to be emerging as part of a new cultural movement, and so the time is ripe for moving away from looking at stands instead of ecosystems. The time is ripe for naming our management intentions and choosing suitable management pathways rather than just focussing doggedly on single outcomes, whatever they might be."

FOR FURTHER READING

Carey, A.B. [and others]. 1999. *Intentional systems management: managing forests for biodiversity.* Journal of Sustainable Forestry. 9(3/4): 83-125.

Carey, A.B. [and others]. 1999. *Ecological scale and forest development: squirrels, dietary fungi, and vascular plants in managed and unmanaged forests*. Journal of Wildlife Management: Wildlife Monographs. 142: 1-71.

Carey, A.B. [and others]. 1999. *Reverse technology transfer: obtaining feedback from managers.* Western Journal of Applied Forestry. 14(3): 153-163.

Carey, A.B. 1998. *Ecological foundations of biodiversity: lessons from natural and managed forests of the Pacific Northwest*. Northwest Science. 72 (special issue no. 2): 127-133.

"This downhill path is easy,
but there's no turning back."

Christina Rossetti 1830-94

Science
FINDINGS

U.S. Department of Agriculture
Pacific Northwest Research Station
333 S.W. First Avenue
P.O. Box 3890
Portland, OR 97208-3890

Official Business
Penalty for Private Use, $300

BULK RATE
POSTAGE +
FEES PAID
USDA - FS
PERMIT No. G-40

SCIENTIST PROFILE

ANDREW B. CAREY is chief research biologist and team leader for the Ecological Foundations of Biodiversity Research Team, Ecosystem Processes Program, Pacific Northwest Research Station. He received his B.S. in forestry and wildlife, an M.S. in wildlife management from the Virginia Polytechnical Institute, and a Ph.D. in zoology and entomology from Colorado State University. Since 1982, he has been leading research teams studying old-growth, naturally young, and managed forests and their wildlife in the Pacific Northwest.

CAREY can be reached at:
Pacific Northwest Research Station
USDA Forest Service Forestry Sciences Laboratory
3200 S.W. Jefferson Way
Corvallis, OR 97331

E-mail: acarey@fs.fed.us
Phone: (360)753-7688

COLLABORATORS

PNW Research Station
Brian Biswell, Bob Curtis, Dean DeBell, Connie Harrington, Randy Molina, Catherine Parks, Dave Thysell, Suzanne Wilson, Todd Wilson

Oregon State University
Wes Colgan III, Mike Holmes, John Sessions, Tim Schowalter, Jim Trappe

University of Washington
Jerry Franklin, Bruce Lippke, Chad Oliver

Olympic National Forest
Kathy O'Halloran