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# Science

F I N D I N G S

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*"Science affects the way we think together."*

Lewis Thomas

## WISDOM FROM THE LITTLE FOLK: THE FOREST TALES OF BIRDS, SQUIRRELS, AND FUNGI



▲ *Thinning brings light into the forest, helping the development of midstory and understory forest layers, which support many small bird and mammal communities. Variable density thinning helps delay canopy reclosure, delaying competitive exclusion.*

*"No idea is so modern  
that it will not some day  
be antiquated."*

Ellen Glasgow (1873-1945)

**E**cosystem management—scientific watchwords of the '90s, or populist panacea? The Northwest Forest Plan began in 1993 to codify what this term implies. Land managers, public and private, took up the rallying cry, and researchers scrambled to quantify and define. Today schoolchildren and even politicians recognize these words.

If only people knew.

"We rely on what we call ecosystem management to produce the economic and ecological attributes we might want in a forest, but there are a great many unquestioned assumptions behind this approach," says Andy Carey. "Almost all ecosystem management rests on untested hypotheses. They are mostly based on retrospective studies and ecological correlations, not formal application of the scientific method." Carey is a research biologist for the PNW Research Station and team leader for the Ecological Foundations of Biodiversity Research Team.

It is particularly important to test our hypotheses as we make decisions about second-growth forests, he says, because

### I N S U M M A R Y

*Ecosystem function—the internal dynamics of a forest—is now recognized as a crucial component to forest health and biological diversity.*

*Pacific Northwest Research Station scientist Andy Carey and others propose that the presence of small critters can be a measure of a forest's health. His research also shows that thinning, rather than legacy retention, produces higher quality trees for timber and plant diversity.*

*Carey's findings suggest that concurrent management of decadence, stand structure, and plant species composition is required for ecosystem management. High-quality wood may result from the use of good forestry techniques, but employing scientifically planned ecosystems can produce economic goods and ecological services.*

they cover extensive portions of all lands—Federal, state, and private—in the Pacific Northwest. These forests hold the greatest opportunity for joint production of timber and ecological values, and for assisting in the recovery of threatened species.

But conversion of so much old-growth forest to managed forest, he adds, has raised significant questions among ecologists about the ability of young, managed stands to sustain wildlife abundance and diversity even without society's continuing demands for timber.

Although some form of ecosystem management is hailed as the potential solution to this massive challenge, Carey suggests we'd better be checking our bearings regularly. "The need to be diligent

←    **KEY FINDINGS**    →

- Compared to legacy management, thinnings produced higher quality trees for timber, greater abundance and diversity of vascular plants without major invasion by exotics, greater abundance of small mammals, and greater activity by birds in winter.

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- Compared to thinning, legacy management produced twice as many flying squirrels (primary spotted owl prey) and greater abundance and diversity of fungi.

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- Neither thinning nor legacy management produced either the variety of vegetation site types characteristic of old forests with gaps or complete small-mammal communities.

along the way is particularly urgent when it involves so much of our vegetation cover. The fact is, the trajectory on which our

decisions send us may prove quite hard to alter over time."

## CHECKING OUR ASSUMPTIONS VIA SMALL CREATURES

Can we be sure, for example, that thinning will help grow high-quality timber and create habitat at the same time? Untested hypothesis. Are we certain that retaining live trees, snags, and coarse woody debris at harvest, with no further active management, is the best way to restore biological diversity to landscapes? Untested hypothesis.

Ecosystem function—the internal dynamics of the forest—is now understood to be crucial to biological diversity and forest health. It's one thing to leave or "recreate" all the pieces. It's another to provide the right conditions for their thriving and interactions.

Because many forest-floor processes act on small-mammal and bird communities, Carey and others have proposed that measures of their diversity and abundance be used as indices of forest ecosystem function. Critters that live in trees, underbrush, litter layers, and decaying wood, include small birds, flying squirrels, voles, deer mice, chipmunks, and shrews.

"The various taxa specialize, of course, but their diets and ecological roles tend to overlap," Carey explains. "Shared functions include curbing insect outbreaks by preying

on invertebrates; serving as prey to birds, reptiles, and mammals; consuming plants, seeds, fruit, lichen, and fungi; aerating the soil and distributing nutrients; and dispersing fungal spores."

An array of animals representing key processes can be used as indicators of change in forest structure, depending on how sensitive they are to forest management, he says. These small creatures thus might provide insights into the assumed relation among biological complexity, and resiliency and survival following disturbance.

The fact that the small animals disperse fungal spores brings the difficult study of forest-floor fungi into the spotlight as well. Although the fungi defy investigation by fruiting underground and dispersing themselves over huge areas requiring thousands of plots, they are nonetheless crucial components of the ecosystem: they are essential for the growth and vigor of many trees, they protect tree roots from many pathogens, they deliver carbon to the soil, and they feed the flying squirrel, which feeds the northern spotted owl. And they are dispersed through the fecal matter of small mammals, thus forming an integral part of the forest-floor ecosystem picture.



Wes Coligen III

▲ *The flying squirrel forms a major part of the diet of the northern spotted owl. It seems to prefer legacy-based management, which also favors its own major food source—fungi.*

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## POTENTIAL LESSONS FROM SECOND-GROWTH FORESTS

**H**ow this whole woodland scene responds to management of second-growth forests, then, should tell a revealing story. For the type of forest we have been left with after more than a generation of clearcutting raises some difficult questions.

"The overall goal would be to promote a diversity of woody species and a continuous column of vegetation that includes low shrubs, tall shrubs, and midstory trees, including deciduous tree species," Carey points out. "But the best management for existing young even-aged stands is still uncertain."

Thinning and legacy retention\* are two commonly recommended alternatives for managing Douglas-fir forests, although few examples exist, and the long-term ecological effects remain unknown. Several recent studies have addressed the ecological effects questions via retrospective studies. Such studies can explore the relation between small mammals and thinning versus legacy retention but cannot demonstrate cause and effect.

Nonetheless, Carey asserts, a key benefit to pursuing retrospective studies is that they can show results in a 1- to 3-year time-frame, whereas studies designed to look at future results (prospective studies) can take 20 to 100 years.

### TO THIN OR NOT TO THIN?

**T**hinning and legacy retention had conspicuously contrasting effects on small-mammal and winter bird abundance, community structure, and biomass distribution in managed Douglas-fir forests, according to Carey. There were also relatively predictable results in timber quality.

Compared with legacy management, thinning produced greater abundance of small mammals and greater activity by birds in winter. There was also greater abundance and diversity of vascular plants without overwhelming invasion by exotic plants, and trees were of higher quality for timber, with fewer than half the number per acre, but with almost twice the diameter at breast height.

\*Legacy retention—Retention of standing live trees, standing dead trees, and fallen trees at harvest—singly and in patches; in patches the objective is to bring a broad array of organisms into the new stand.



### MANAGEMENT IMPLICATIONS



- Management for process is crucial. Concurrent management of decadence, stand structure, and plant species composition is required for ecosystem management.
- "Keeping all the pieces" through legacy retention and passive management does not guarantee fully functional ecosystem dynamics; reserve-based conservation should not be the only approach to maintaining biodiversity.
- Maintaining habitat breadth, including species and life-form diversity among vegetation types, is a vital ecosystem process.
- High-quality forestry can produce high-quality wood but not intact, fully functional ecosystems. Active, intentional, scientifically planned ecosystem management however, can jointly produce economic goods and ecological services.

In a suite of studies, fungi, vascular plants, forest-floor small mammals, tree-dwelling rodents, winter birds, and timber were measured in eight stands in each of two forests. The stands were managed for 55 to 65 years either with retained legacies (snags, coarse woody debris) and no further management, or with site preparation (including removal of dying and dead trees and logs) and multiple thinnings.

"These studies are improving our understanding of how disturbance, including silvicultural management, influences ecosystem processes such as humus development, plant community organization, decadence, and canopy stratification," Carey says.

On the other hand, legacy management produced twice as many flying squirrels, the primary prey of the northern spotted owl, and a greater abundance and diversity of fungi.

"What is just as important to note, however, is that neither strategy produced complete small-mammal communities or the variety of vegetation types characteristic of old forests with gaps," Carey says. "This suggests strongly that the idea of 'keeping all the pieces' through legacy retention benefits some ecosystem components but not others. Perhaps it tells us that, in fact, not all the pieces are kept." High-quality forestry practices may produce high-quality wood, but not intact, fully functional ecosystems.

Without intentional management of these processes, he adds, timber harvesting can lead to a decline in forest legacies, simplification of stand structure, and lowered habitat quality with consequences for nutritional, or trophic, webs.

Researchers examined small-mammal abundances and community patterns under the two management strategies. They investigated population demographics for each selected species, then finally contrasted results with neighboring studies in which old-growth small-mammal communities were compared to young managed stands on the Olympic Peninsula and young natural stands in the Cascade Range in southern Washington.

A closer look at what happens under these two management scenarios turns up the apparent causes of the discrepancies.

Thinning enhances understory and midstory development of the forests by changing the structure of the canopy, opening small gaps, and thus increasing light and air movement to the lower levels. Early thinning, when a stand is reestablishing after harvest, may help maintain a mix of tree species and continued development of the understory shrubs and herbs, Carey says. They hasten the development of forest structure and stature.

"As the canopy closes in the developing-stand, or stem-exclusion, stage, thinning

from below may help continue this understory development, thus promoting shade-tolerant species, and hastening the stand's progress toward full and complex stature," he says.

## WHICH PIECES ARE MISSING?

**A**lthough no particular "piece" may appear to be missing, the conditions for various ecosystem processes often are, according to Carey.

Five processes seem pre-eminent in the development of Douglas-fir/western hemlock forests of the Pacific Northwest, he explains: crown-class differentiation (dominance and suppression of different individual species), decadence, canopy stratification, understory development, and development of habitat breadth (a diverse array of life forms and plant species of mixed ages).

Interactions among these processes promotes complexity and diversification in forests, Carey says. The more processes that remain fully functional, the more they contribute to overall forest health and resiliency through time.

## MANAGING FOR PROCESSES

**T**hinning seems to have achieved slightly better results overall for small mammals, birds, and their interactions with fungi, and has the potential to accelerate most ecosystem processes except decadence. But traditional commercial-style thinning has some obvious drawbacks, according to Carey.

"Thinning with even spacing, as it is usually done, can retard the development of a diverse, multilayered canopy, and of habitat breadth in general. Light thinning may not allow vigorous understory development before the canopy recloses, and heavy thinning may disrupt canopy connectivity, increase windflow within the forest, and cause the forest to become drier and warmer," he explains.

Neither legacy nor thinned stands developed the midstories or the array of plant species (and associated seed, fruit, and nut production), or the levels of decadence,

Legacy retention does provide some of the elements required by wildlife in old-growth forests. But dense, overstocked stands tend to close canopies quite rapidly, thereby vastly reducing development of midstory

Decadence provides the best example of a process not fully understood in the past, and one which can teach a great deal when it's missing from an ecosystem. The last 20 years have seen a heavy focus on providing snags for cavity-using wildlife, and logs for multiple forest-floor dynamics. In turn, many of these creatures are regulatory mechanisms for forest insect populations. But decadence in the forest is not just about snags and logs, Carey points out.

"Live trees with broken or rotten tops, damaged trees from windfall or fire, insect attacks, all begin a decay process that contributes to creating gaps. Not only does this affect understory vegetation and how light and moisture can stimulate its development, but it also provides a continuing source of coarse woody debris for the forest floor."

that would be expected in late-seral forests.

But Carey proposes variable-density thinning as a surrogate for multiple small- and intermediate-scale disturbances that add diversity to vegetation structure and plant communities in Douglas-fir forests. The uneven patchwork of heterogeneous forest cover, which results are important in developing complexity, he says, favoring dominance and subordination processes, and keeping at bay the exotics, which thrive on simplified ecosystems.

Furthermore, variable spacing of thinnings can be done on a scale that markedly reduces disturbance of existing coarse woody debris on the forest floor. When combined with active and intentional management for decadence and other processes, it would appear that the "pieces" might more effectively be kept in place this way, Carey says.

and understory characteristics. They then remain in the competitive exclusion stage for long periods, tending to favor dominance by shade-intolerant species.

Because decadence is so fundamental to structuring the ecosystem, researchers are investigating ways of enhancing the process, particularly in previously clearcut second-growth forests, where entire stands and all forms of decadence were removed by harvest. Techniques include thinning methods that leave wounds on surrounding trees, creating cavities, and inoculating trees with local top rot pathogens.

Management for decadence, it seems, needs to be pursued throughout the life of a stand. "Decadence may even be the most crucial of the essential ecosystem processes, but it is also the hardest to deal with. All the others can be at least approached by refining and adapting current management methods," Carey says.

Several experimental tests combining elements of these approaches are underway. One incorporates variable-density thinning, legacy retention, and introducing top rot through creating cavities and inoculating decay fungi. Another combines variable-density thinning with creating coarse woody debris structures from small trees felled during thinning.

"It is important that we at least be aware that the reserve-based approach to protecting biodiversity could lead us in unpredictable directions. We shouldn't put all our biodiversity eggs in that one basket," says Carey. Hence his persistent investigations of alternatives to both no management and traditional management.

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## WRITER'S PROFILE

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## THE MEASURE OF SUCCESS

**H**ow will we measure the success of new approaches, given the complex nature of forest response at all points during its rise to maturity?

“Measures of ecosystem function, biotic integrity, and public acceptability will need to be developed. We need to remember that no single silvicultural system is appropriate for all lands, and various pathways could lead to the desired end,” Carey notes.

The integrity of the small-mammal community on the forest floor, its abundance and diversity, is clearly a robust measure of ecosystem function, Carey believes. “These indepth studies provided specific, quantitative data on elements of forest structure and composition important in supporting food webs and organisms at various levels.”

Developing indicators of biotic integrity—measures of forest resiliency, health, and complexity—would provide better measures overall than monitoring to see if some number of rare and cryptic (difficult to locate) species is present. Carey has concluded that there are too many taxa potentially sensitive to forest management for species-based monitoring to be realistic.

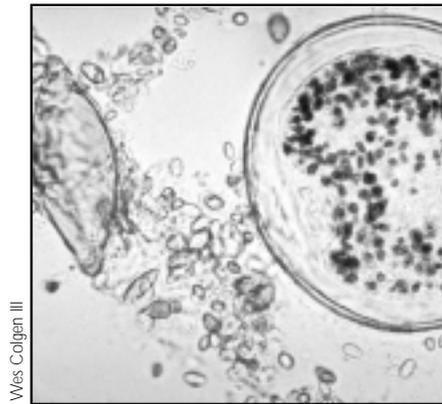
And public acceptability? This is an unexplored area, an area in which education and training need to be used in innovative ways to determine what people find pleasing. Is a thick understory too scary? Is the level of birdsong sufficient, or even important? What is the perception of biodiversity and its value?

“My hope is that if we can develop these kinds of indices in a compelling manner, it may be that we can seek to achieve some kind of grudging consensus, agreement among the suspicious super-majority, that could lead us in the right direction,” he says.

If the indices are clearly supported by measurable science, if ecosystem management can be **demonstrably** employed to the benefit of forests and society, then the future of that vast majority of second-growth Douglas-fir forests in the Pacific Northwest, and all the people, creatures and their ecosystems it supports, might be far more assured than it is now.

*“A land ethic for tomorrow should be as honest as Thoreau’s Walden, and as comprehensive as the sensitive science of ecology. It should stress the oneness of our resources and the live-and-help-live logic of the great chain of life.”*

Stewart Udall, *The Quiet Crisis*, 1963



Wes Colgren III

▲ *Fungi are crucial components of the forest, delivering moisture and nutrients to tree roots and protecting them from pathogens, delivering carbon to the soil, and feeding small mammals. They are dispersed through small-mammal faeces.*



▲ *Legacy retention holds snags and coarse woody debris in the forest, but passive management allows rapid canopy closure, a long competitive exclusion stage, and little understory development.*

### FOR FURTHER READING

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