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Pacific Northwest
Research Station

Science
FINDINGS

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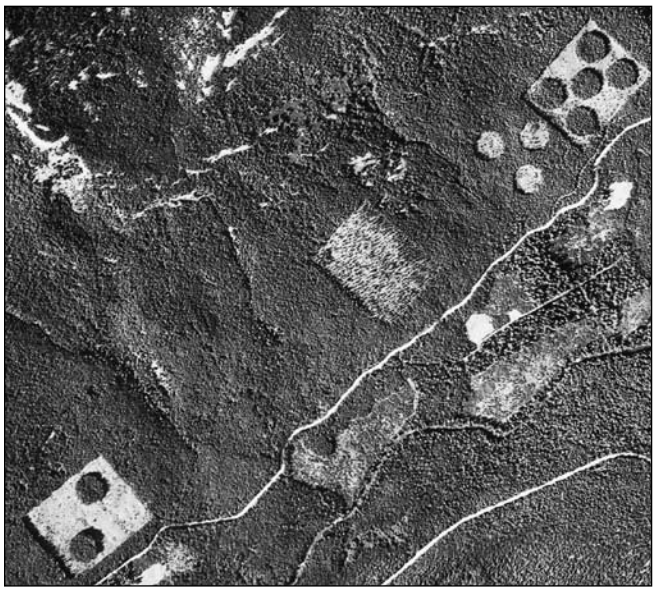
"Science affects the way we think together."
Lewis Thomas

GREEN-TREE RETENTION IN HARVEST UNITS: BOON OR BUST FOR BIODIVERSITY?



Aerial view of the experimental treatments at the Butte block in southern Washington.

"The true method of knowledge is experiment."
—William Blake

Between trees and man there is a rift in the perception of time, and forest managers have no choice but to yield to the pace of the trees. This can make innovations in forest management difficult to evaluate. Nonetheless, innovation is key to meeting society's changing expectations. It is not just timber anymore. Biodiversity, recreation, aesthetics, and clean water all share top billing with a sustainable crop of timber. And although novel silvicultural strategies are being promoted to meet these complex demands, without the benefit of time, it is difficult to know exactly how well they will achieve their goals.

In the Douglas-fir forests of the Pacific Northwest, clearcutting followed by planting has long been the dominant regeneration strategy. Increasingly, however, forest managers are leaving a portion of the trees onsite during harvest of mature stands. This tactic is called structural or green-tree retention; it is designed to retain or accelerate development of forest structures and plant and animal species that are associated with older, multilayered forests. These retained trees are thought to ameliorate microclimatic conditions and enhance habitat for plants and animals that would not survive in a traditional clearcut. What's more, by leaving mature trees within harvest units, managers hope to improve the scenic quality and recreational potential of the landscape.

According to Charley Peterson, a program manager at the Pacific Northwest (PNW) Research Station in Portland, Oregon, the benefits of structural retention—although very promising—were largely speculative when the Northwest Forest Plan was established. "The Forest Service has shifted to ecosystem-based management, and structural-retention harvesting is a major part of that. The agency is starting to think more about what is left behind than what is taken out. But there are still many

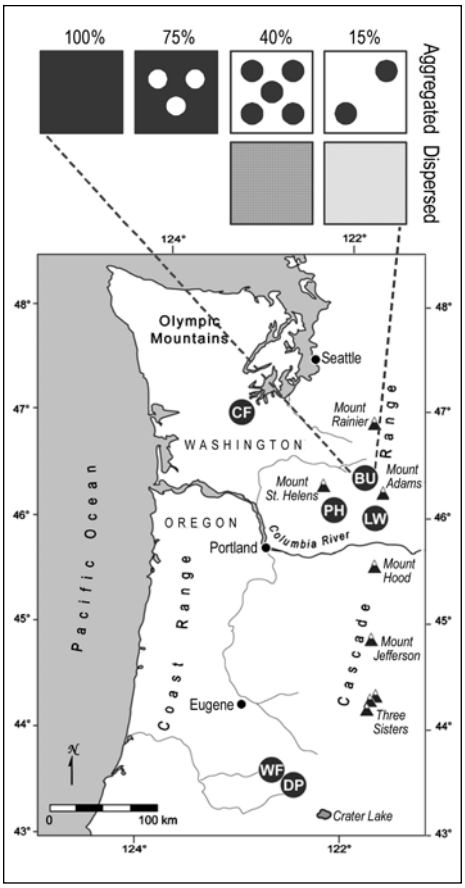
IN SUMMARY

In response to societal concerns about clearcutting in the Pacific Northwest, structural or green-tree retention is now an integral part of harvest prescriptions on federal lands. However, the benefits of different levels or patterns of retention for the ecological, microclimatic, and aesthetic attributes of resulting forest stands remain speculative. The Demonstration of Ecosystem Management Options (DEMO) study was designed to address this information gap by evaluating the ecological effects of green-tree retention in mature Douglas-fir forests. DEMO is an interdisciplinary study that was established at six locations in Washington and Oregon, and includes six harvest treatments that enable researchers to contrast the effects of retention level (15 to 100 percent of original basal area) with spatial pattern (dispersed vs. aggregated) for a variety of response variables. Initial results indicate that the lowest level of retention may be inadequate to dampen the detrimental effects of clearcutting for many plants and animals associated with older forests, and also generates negative responses by the public. In addition, early results suggest that the amount of retention may be more important than its pattern. However, by aggregating retained trees in unharvested patches of at least 2.5 acres, managers can provide refuges with ecological and microclimatic conditions that enable many sensitive species to persist, at least in the short term. A combination of intact patches and dispersed trees may be the best strategy for green-tree retention.

questions about how best to do it: How much should managers leave? And in what spatial pattern?"

The large-scale and long-term experiments that are required to answer these basic questions are extremely challenging to establish and maintain. Nonetheless, they are critical for evaluating the ability of structural retention to live up to expectations. There are surprisingly few such experiments around the world that are rigorously designed to enable strong inferences to be made about the relative importance of amount and spatial pattern of retention on ecological responses. One such experiment in the Pacific Northwest is the Demonstration of Ecosystem Management Options (DEMO) study.

The DEMO study is designed to evaluate the ecological effects and public perceptions of green-tree retention in mature Douglas-fir forests of western Washington and Oregon, and was initiated in 1993 under a Congressional mandate. Partners in the private sector, academia, and public research and management agencies crafted a comprehensive study design based on pilot studies and more than the customary peer review.



The DEMO treatments were replicated in six locations. They include four levels of retention (15 to 100 percent of original basal area) and two spatial patterns (dispersed evenly throughout the unit and aggregated in 2.5-acre patches).

KEY FINDINGS

- For a number of microclimatic and ecological attributes, as well as public perceptions of scenic beauty, 15-percent green-tree retention resulted in responses to harvest that were not significantly different from those in a clearcut.
- Amount of retention appears to have a greater influence on many types of forest-dependent species than does pattern of retention. In aggregated-retention treatments, forest patches and harvested areas contain strongly contrasting environments. When responses are averaged, they differ little from those of dispersed treatments, which have intermediate levels of disturbance and environmental stress.
- Many plant and animal species that are sensitive to timber harvest were able to persist in retention patches of 2.5 acres; consequently, such patches may serve as local sources of recolonization into adjacent harvested areas as the new stand develops.

"The design process for DEMO was one of the more intensive planning efforts that I've been involved in," says Keith Aubry, a research wildlife biologist at the PNW lab in Olympia, Washington. "Before felling a single tree, we reconciled every comment and criticism from 12 peer reviewers. This sometimes meant revisiting parts of the study, and eliminating aspects of the original design to make room for new ideas."

Eventually the partners decided on a series of six treatments that spanned a range of retention levels and spatial patterns: 15- and 40-percent retention in both dispersed and aggregated patterns; 75-percent aggregated retention; and 100-percent retention (an unharvested control). All of the treatments were replicated at six locations in western Washington and Oregon.

Finding sites large enough and sufficiently homogeneous to accommodate all six treatments was a challenge. Each harvest treatment is 32 acres, which is much larger than a typical research plot. "We wanted to implement the DEMO experimental treatments at an operational scale. In the end, I think it built confidence that managers could effectively apply these types of harvests," says Peterson.

By 1997, pretreatment data had been collected, and loggers were brought in to fell trees in some rather unique arrangements.

Looking down on the DEMO harvest design, you'd be forgiven for thinking that managers were playing dice with the forest. By aggregating trees in the 40-percent retention into five 2.5-acre circles within a square 32-acre harvest unit, the site looks strikingly like a giant die cast to the number five. Similarly, the 15-percent aggregated-retention treatment resembles a die cast to two. Managers would not necessarily implement the DEMO treatments as designed. Instead, knowledge gained from these strictly controlled manipulations will provide information that can be used to design silvicultural strategies to meet local management objectives.

By replicating the 15- and 40-percent retention levels in both dispersed and aggregated patterns, the DEMO study allows researchers to statistically disentangle the questions of how much to retain and in what pattern?

Dispersed-retention treatment (top) and aggregated-retention treatment (bottom) at the Paradise Hills block in southern Washington.

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HOW MUCH TO RETAIN?

Exactly how many trees to retain depends on the objectives at hand. Certainly, forest managers expect a species that is associated with continuous canopy cover to require a higher level of retention than one that favors openings. Unfortunately, there is scant information for matching retention levels to management objectives. That's why DEMO spans a wide range of harvest options.

A look at initial responses, 2 to 7 years after harvest, shows that the percentage of trees retained can make a substantial difference for several important response variables. For example, for microclimatic conditions such as air and soil temperature, and for many species of forest understory plants, 15-percent retention does not appear significantly different from a clearcut.

"In addition, damage to retained trees in dispersed treatments was particularly high at 15-percent retention due to the higher intensity of felling and yarding operations. Subsequent mortality of residual trees was also greatest in these treatments," says Charlie Halpern of the University of Washington. On the other hand, survival of planted seedlings was sometimes unaffected by retention level (e.g., Douglas-fir) or was greater at lower retention (e.g., ponderosa pine).

Initial responses of small mammals were mixed. "Responses were strongly influenced by regional variation in habitat conditions and by differences in the mammal species that occur in each region," says Aubry. "For example, at mid- to higher elevations in the Washington Cascades, 15- to 40-percent retention may be sufficient to benefit small mammals, whereas in the southern Oregon Cascades, higher amounts of retention may be needed to have the same effect."

In contrast, responses of ectomycorrhizal fungi (the fungi that live belowground in concert with tree roots) were generally proportional to level of retention; compared to controls, production of fungal sporocarps (fruiting bodies) was reduced most in the 15-percent treatments and least in the 75-percent aggregated treatment.

Researchers and managers discuss the objectives and early results of DEMO at one of the experimental sites.

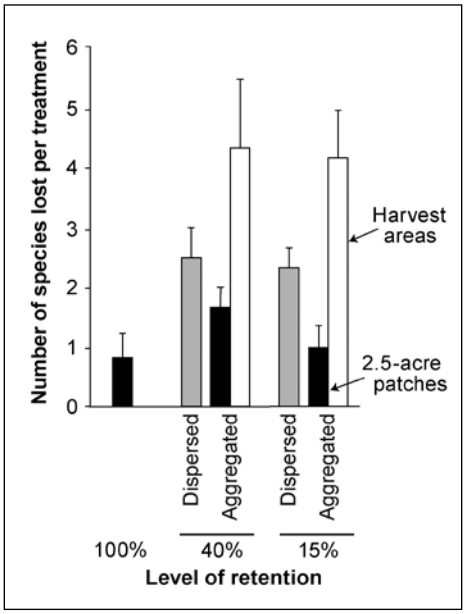
"Canopy-nesting and bark-gleaning birds responded negatively to 15-percent retention, but responses of other bird species were highly variable" says Aubry.

As for aesthetics, surveys of public acceptability revealed broad, passionate opposition to clearcutting. The 15-percent retention treatment received similar opposition, while there was general acceptance of harvest once the level of retention reached 40 percent.

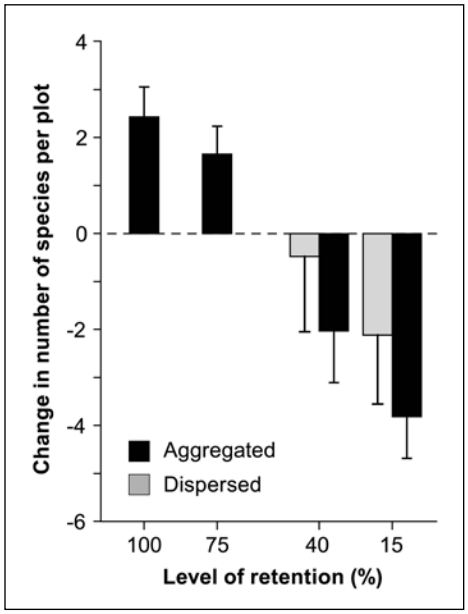
WHAT PATTERN TO RETAIN?

Prior to initiating these studies, it was generally assumed that treatments in which trees were left in relatively large patches would support a greater abundance and diversity of forest-dependent species than treatments in which trees were uniformly dispersed across the harvest unit. However, scientists were surprised by initial responses to retention pattern.

"Contrary to initial expectations, loss of understory plant species was comparable in the dispersed and aggregated treatments. This resulted from higher losses in the harvested areas of aggregated retention, balanced by much lower losses in retention patches," says Halpern. "Declines in forest-floor bryophytes—mosses and liverworts—were relatively large at both 15- and 40-percent retention, but pattern of retention had little effect on the magnitude of decline. Declines in species frequency and richness were consistently greater in the harvested areas of aggregated treatments than in dispersed treatments."



On average, extinctions of herbs associated with older forests were comparable between dispersed and aggregated treatments. However, losses were consistently highest in the harvest areas of aggregated treatments.



Forest-floor bryophytes showed large declines in diversity at 15- and 40-percent retention. Differences among these treatments were not significant, but losses tended to be greater in aggregated than in dispersed settings.

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

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

Keith Routman, layout
kroutman@fs.fed.us

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Similarly, for small mammals and birds, there were few differences between aggregated and dispersed treatments at either level of retention.

"One common trend in our initial results was that for many ecological and microclimatic variables, treatments with aggregated retention functioned as a mix of clearcut and unharvested forest, with dispersed treatments intermediate between the two," says Aubry. "So, when local responses were averaged at the scale of entire treatments, researchers found few differences between the two patterns of retention."

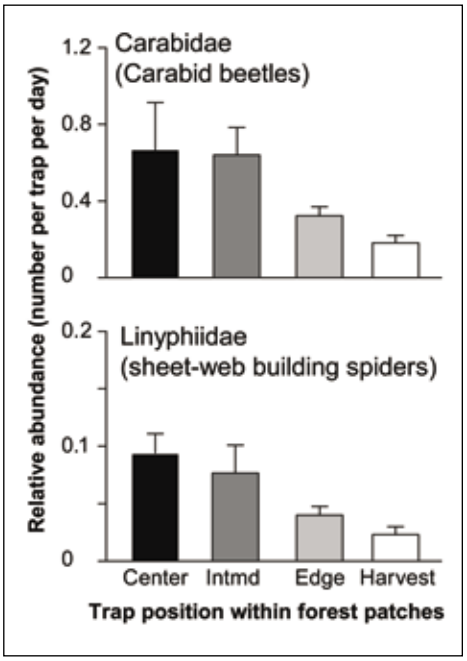
However, there appeared to be a cost to harvesting trees in a dispersed pattern. "Retaining trees in dispersed fashion throughout a unit without causing associated damage is difficult," says Halpern. "Relative to aggregated treatments, there is less room to maneuver. Not surprisingly, there was significantly higher damage to residual trees in dispersed treatments and greater subsequent mortality from windthrow, particularly at the lowest level of retention. In contrast, there was no more tree death within the forest aggregates than in the unharvested controls."

Interestingly, despite the potential ecological benefits of retaining trees in large patches, research on public perceptions of scenic quality indicates that aggregated retention is generally perceived as ugly because of the cleared areas between the aggregates.

A FOREST PATCH FOR A LIFEBOAT

Conservation biologists have long suggested that patches of remnant forest within a larger matrix of disturbed or cleared land could function as "lifeboats" or refugia, enabling species sensitive to disturbance or environmental change to persist until the surrounding landscape regenerates. However, this requires that environmental conditions within these patches are not severely altered. Early findings from DEMO suggest that for some species, 2.5-acre patches may keep populations afloat, at least in the short term.

"Forest aggregates experienced edge effects, including elevated light and air temperature to distances of 30 to 60 feet, up to one-third of the radius of the patch. These effects were stronger and penetrated deeper into south- and west-facing edges, but were relatively shallow along north- and east-facing edges," Halpern explains. As a result, patches were large enough to contain some areas with an understory climate comparable to that found in the undisturbed controls. These interior areas may serve as refugia for forest herbs, mosses, and other species that are sensitive to the harsher microclimates in the adjacent harvest areas. Indeed, in the short term, mosses showed limited responses to edge effects, and for the forest herbs that showed declines, effects were limited to the margin of forest patches.

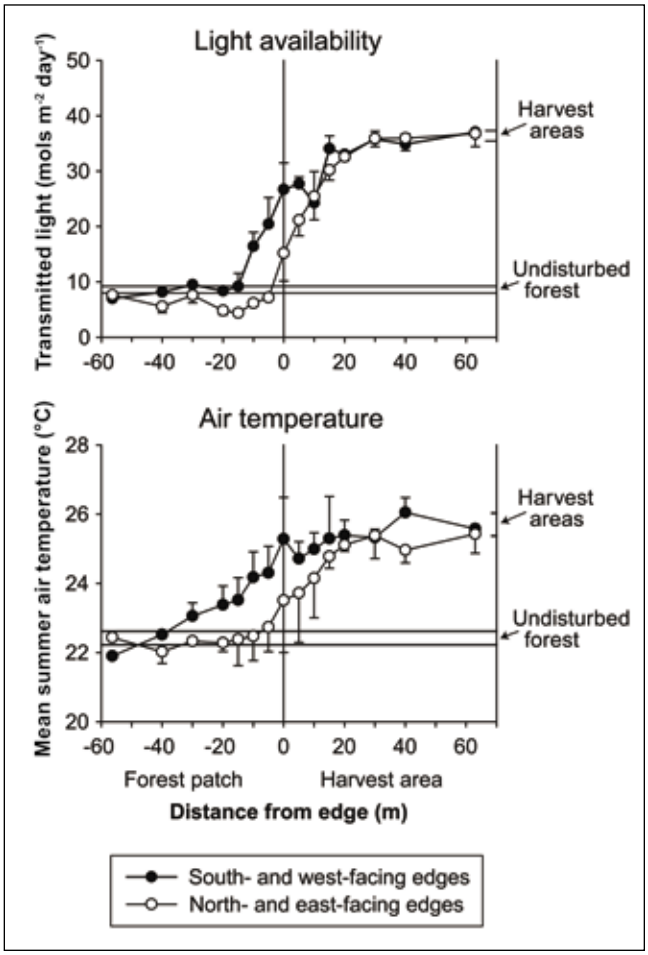


Many groups of forest-dependent litter arthropods showed declines in abundance with proximity to the edge of the 2.5-acre forest patches.

Although retention patches were more amenable than harvested areas for some species, they were less habitable than undisturbed forest. Ground-dwelling spiders and beetles, for example, showed significant declines with proximity to forest edge, resulting in lower levels of abundance and diversity in the aggregates than in the controls.

"The aggregates were necessary for retaining populations of the western red-backed vole, a fungus-eating small mammal closely associated with interior forests," says Aubry. "However the relative abundance of this species was lower in the aggregates than in the larger forest controls, suggesting that the aggregates had reduced habitat value for this species."

According to the researchers, when you consider the full array of ecological responses, one surprising finding is that level of retention is probably more important for conserving biodiversity than is pattern. "Some mix of dispersed and aggregated retention will probably be best from an operational forest management perspective," says Aubry.



Effects of harvesting on understory microclimate are apparent at the edges of 2.5-acre forest patches, but decline substantially toward the interior, particularly on north- and east-facing edges. As a result, some portions of the patches contain microclimatic conditions similar to undisturbed forest.

WRITER'S PROFILE

Jonathan Thompson is a science writer specializing in natural resource issues and ecology.

LAND MANAGEMENT IMPLICATIONS

- Retention levels greater than 15 percent (the current minimum standard in the Northwest Forest Plan) may be needed to effectively minimize harvest damage to residual trees, retain sensitive plants and animals, ameliorate harsh microclimatic conditions, and gain acceptance by the public.
- Retaining trees in 2.5-acre patches greatly reduces initial logging damage and the potential for mortality from windthrow, especially at lower retention levels.
- Early results indicate that for many management objectives, a mix of dispersed and aggregated retention is likely to provide the greatest ecological and microclimatic benefits, and will also reduce negative responses by the public.

DEMONSTRATING THE POWER OF EXPERIMENTAL STUDIES

The research findings pouring out of the DEMO study are impressive both in their quantity and breadth. There simply has not been much previous research on structural retention, and the rigorous experimental design allows scientists to make strong inferences about ecological responses.

"Past research has primarily been in the form of individual case studies," says Peterson. "DEMO was designed to cover a range of silvicultural treatments with a statistical design that allows researchers to separate the effects of level vs. pattern, to evaluate their potential interactions, and to generalize those findings over a large area for a diversity of response variables."

Through workshops and publications, DEMO is now paying dividends to the forest managers who made it possible in the first place.

"It is clear to everyone involved that DEMO was possible only because of the commitment of on-the-ground managers," adds Peterson. "It has been a diversion for them to have to coordinate their day-to-day activities around DEMO's research goals and the peculiarities of the study design. It's to their credit that this study was implemented as designed and that the integrity of the research sites remains intact up to 10 years after harvest."

One of the next challenges for DEMO involves a reassessment and refinement of various components of the study to determine how they can be improved to more effectively address emerging research and management issues. Early findings have provided important information on short-term responses to disturbance and environmental changes. However, most of the DEMO story has yet to be told. The most useful and intriguing results will emerge in future decades as forest canopies close and stands ultimately grow into multilayered forests.

"To change something, build a new model that makes the existing model obsolete."

—Buckminster Fuller

PARTNERS

Project managers:

Umpqua National Forest: Rick Abbott
Gifford Pinchot National Forest: Jon Nakae
Washington Department of Natural Resources: Pete Holmberg

Principal investigators:

University of Washington: Charles Halpern and Cara Nelson (vegetation); Janet Erickson, Robert Gitzen, Matthias Leu, David Manuwal, Stephen West (wildlife); and Susan Bolton (hydrology)

Oregon State University: Douglas Maguire (vegetation), Daniel Luoma (fungi), Timothy Schowalter (invertebrates), and Christine Maguire (wildlife)

University of Oregon: Robert Ribe (public perceptions)

Cascadien, Inc.: Juraj Halaj (arthropods)

Pacific Northwest Research Station: Troy Heithecker (microclimate)

FOR FURTHER READING

DEMO Web site: http://www.cfr.washington.edu/research.demo/

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Pacific Northwest Research Station
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SCIENTIST PROFILES

CHARLEY PETERSON is Program Manager for the Resource Management and Productivity Program of the Pacific Northwest Research Station. Prior to joining the Station in 1992, he worked at the University of Washington in Seattle evaluating responses of forests to nitrogen fertilizer and environmental influences, and impacts of Agent Orange on the forests of South Vietnam. He also worked with the EPA in Corvallis, Oregon, synthesizing information from seedling studies to estimate regional forest responses to acid rain and ozone. Since coming to the Station, his work includes providing new genetic and silvicultural tools to help land managers balance wood production objectives with ecological and social objectives, such as native plant restoration, riparian systems, public acceptance, and biodiversity through large-scale harvest experiments (e.g., DEMO).

KEITH AUBRY is a research wildlife biologist with the USDA Forest Service, Pacific Northwest Research Station in Olympia, Washington. He has been studying the ecology of terrestrial wildlife in the Pacific Northwest for more than 25 years, including community studies of amphibians, small mammals, and birds in both managed and unmanaged Douglas-fir forests. His current research activities include field studies of the pileated woodpecker, fisher, Canada lynx, and wolverine in the Pacific Northwest; the historical zoogeography and genetic affinities of the fisher, wolverine, and red fox in North America; and the application of genetic information to wildlife research and conservation.

Peterson and Aubry may be contacted at:

Peterson:
Pacific Northwest Research Station/USDA Forest Service
Forestry Sciences Laboratory
620 SW Main Street, Suite 400
Portland, OR 97205
Phone: (503) 808-2026
E-mail: cepeterson@fs.fed.us

Aubry:
Pacific Northwest Research Station/USDA Forest Service
Forestry Sciences Laboratory
3625 93rd Avenue SW
Olympia, WA 98512
Phone: (360) 753-7685
E-mail: kaubry@fs.fed.us

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