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

IF A TREE FALLS IN THE WOODS, WHO WILL MEASURE IT? DECAID DECAYED WOOD ADVISOR

Bruce Marcot

Standing dead trees, called snags, provide wildlife habitat and other ecosystem services.

"Dead wood, often thought wasted in its rich rotting, feeds all the small rotters and, through them, finally the earth itself."
—Robert Michael Pyle

It is a conspicuous truth, apparent to the most casual observer, that the ecological functions of a tree continue long after it ceases converting sunlight to cellulose. As a tree slowly decays, it may cycle through many vocations to which it was ill-suited when fully alive, variously serving as a bat roost, bear den, fungal refuge, or many other roles.

To appreciate the ecological roles of legacy trees, let's consider a hypothetical biography of a large dead Douglas-fir in the Pacific Northwest. Assuming it died standing, our tree begins the afterlife as a tall wooden tower tucked into the forest; a snag ripe for excavation. Woodpeckers and other excavators begin by hollowing nest sites. They have known for longer than the carpenter that strong wood, properly crafted, yields a dry and safe home to raise a family. What's more, many woodpeckers are ambitious homebuilders and often leave previous nest sites in favor of more recent construction. This is a fortunate turn of events for those birds and mammals not gifted with sharp beaks and strong necks but who, nonetheless, enjoy the benefits of woodpecker hollows—these freeloaders, such as western blue birds and chestnut-backed chickadees, are referred to as secondary cavity nesters.

As years pass, our snag decays through a series of habitat conditions. With every storm, limbs fall and bark peels. Activity of tiny, inconspicuous life forms—including the work of beetles, ants, fungi, and others—hasten decomposition. Each phase of wood decay provides new niches for a unique community of organisms. Sloughing bark along the trunk is a day-time roost for long-eared bats and a nest site for brown creepers. Bark piles at the tree's base form habitat for snakes, lizards, slugs, and clouded salamanders. Wood fungi may cause the standing tree—alive or dead—to decay and hollow out, providing important habitat for bears, swifts, woodpeckers, and many other animals. Eventually the roots relinquish their hold on the trunk, or the trunk snaps, and the tree falls to the forest floor. Insects, fungi, and weather continue the decay process. The hollow log can now become a den for fishers, black bears, or other large mammals. Or bears, along with pileated woodpeckers, may tear apart the down log in search of insect food. This further fragments the wood into pieces that add organic matter into the forest floor, which helps keep the soil productive.

IN SUMMARY

Decayed wood plays many critical roles in forest ecosystems. Standing dead trees, called snags, provide habitat for a suite of wildlife, including several species of birds, insects, bats, and other mammals. Down wood provides wildlife habitat and performs ecosystem services such as releasing humus, nitrogen, and phosphorus into the forest soil, storing pockets of moisture, and stabilizing soil on slopes. Root wads, tree stumps, hollow trees, and partially dead trees also perform important ecological roles as wildlife habitats and sources of soil organic matter.

DecAID Advisor is an on-line decision-aiding system to help managers plan for wood decay elements for biodiversity in forests of Washington and Oregon. DecAID Advisor is a statistical "meta-analysis" and synthesis of a vast amount of wildlife and inventory data. It does not make decisions for managers, but instead, DecAID Advisor advises on size and amount of snags, down wood, and other wood decay elements to meet management objectives and to help set those objectives by forest type and structural condition class. It is the first decision-aiding tool of its kind, given its scope of species, inventory data, and topics provided.

The importance of dead wood as habitat cannot be overstated, but it is hardly the complete story. "The ecosystem services of decaying wood extend well beyond wildlife," says Bruce Marcot, a research wildlife biologist at the Pacific Northwest Research Station in Portland, Oregon. "Down wood serves as moisture reservoirs, and in moderation, provides microsites for beneficial mychorrizal fungi and plants that aid in forest recovery after prolonged drought or fire. Moreover, large pieces of wood work into the soil where they serve as time-release capsules of humus, phosphate, and nitrogen."

The afterlife of our Douglas-fir may continue for a century or more. And, in a sense, it continues indefinitely as the tree's organic matter is recycled into future generations of plants and animals. Given the efficiency of nature and the ubiquity of dead trees, perhaps it shouldn't be surprising that their many ecological roles may be of interest to ecosystem managers; but they're impressive nonetheless.

Professional forest managers are well aware of the functions of dead wood. "Maintaining an adequate level and mixture of these habitat elements, in concert with other objectives, can be a challenging task for any land manager," says Marcot.

KEY FINDINGS

- DecAID Advisor is an on-line decision-aiding system to help managers plan for wood decay elements for biodiversity in forests of Washington and Oregon. It is the first decision-aiding tool of its kind, given its scope of wildlife species, inventory data, and topics provided. DecAID can be found at http://wwwnotes.fs.fed.us:81/pnw/DecAID/DecAID.nsf.
- DecAID provides an empirical basis for setting landscape objectives for snags, down wood, and other wood decay elements for wildlife and to meet "natural" and desired conditions.
- DecAID clearly shows the empirical information underlying the pattern summaries of wildlife and inventory data. It does not dictate answers, but rather presents the summaries in the form of "tolerance intervals" (akin to confidence levels and probabilities) which fit well into a very flexible risk analysis and risk management framework.

A NEW TOOL

What managers need is some sort of tool or database where they can obtain information regarding the abundance, size, and distribution of decaying and dead wood and its associated wildlife and functions. Enter DecAID Advisor: "DecAID Advisor is a Web-based planning tool and advisory system that presents a synthesis of research data on wildlife use of wood decay elements and inventory data on snags and down wood in forests of Washington and Oregon" explains Janet Ohmann, one of DecAID Advisor's primary architects and a research forester at the PNW Research Station in Corvallis, Oregon.

"We created DecAID Advisor, not to make decisions, but rather to bring the best information possible to managers and help them make decisions, given their specific goals for the forest," says Ohmann.

"The intended audience for DecAID—which is shorthand for decayed wood advisor and decision aid—includes forest managers, forest planners, wildlife biologists, and silviculturists who need to either identify target size and amounts of snags or down wood or who need to determine the extent to which existing snag and down wood targets will meet their objectives," says Marcot.

Consider a forest planner working for the U.S. Forest Service charged with providing habitat for the red-breasted nuthatch, a secondary cavity-nesting bird common in forests of the West. Through consultation with district silviculturists and biologists, the planner knows the density and size distribution of available snags within the forest. But are these resources adequate to provide for the nuthatch? Here is where DecAID Advisor comes in. The planner can query DecAID Advisor, by providing the location and habitat type (say, for example, the Oregon Coast Range, large conifer forest) and in return, DecAID Advisor will list

Bruce Marcot

American kestrels, like many birds, use dead wood as habitat.

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

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the size and abundance of snags that have been associated, through previous wildlife studies, with nuthatch populations. The planner can then compare this information with the existing snag resources and make an informed decision regarding nuthatch habitat availability at various levels of assurance.

"It is not a simulation model. It is rather a compilation of field information, a summary of scientific data that utilizes a statistical method for combining information that has been collected in different formats over a long period. DecAID Advisor became possible when we—as a scientific community—reached a critical mass of information pertaining to dead wood and wildlife. DecAID Advisor is a synthesis of data from over 17,000 field plots and information gleaned from dozens, perhaps hundreds, of wildlife studies in Oregon and Washington," Marcot explains.

DecAID is the result of an interdisciplinary team of nine specialists in wildlife biology, forest ecology, forest inventory, and insect and fungal ecology, and was possible only through the collaboration across USDA Forest Service management and research and USDI Fish and Wildlife Service. Among the team members, Kim Mellen, Bruce Marcot, and Susan Livingston contributed to the wildlife habitat use sections of the Web site. Janet Ohmann and Karen Waddell analyzed, summarized, and interpreted the inventory data. Beth Willhite and Bruce Hostetler contributed descriptive information on insects and pathogens and summarized the insect and disease components of the forest inventory data. Tina Dreisbach contributed information on fungal relationships with dead wood. Marcot, Ohmann, and Mellen developed statistical analysis procedures, and Catherine Ogden provided technical and administrative oversight and coordination.

DECAID ADVISOR FILLS THE INFORMATION GAPS

At regular intervals, the Forest Service remeasures a network of permanent forest inventory plots distributed throughout the country. Among other things, these plots contain information regarding the size and abundance of standing and down wood. When developing DecAID Advisor, Ohmann, along with Karen Waddell, forest analyst with the PNW Research Station in Portland, Oregon, amassed the dead wood data from all the plots within Washington and Oregon. The data are collected in the regional forest inventory programs of Current Vegetation Survey (federal land) and Forest Inventory and Analysis (nonfederal land), which offer a snapshot (actually, over 17,000 snapshots) of the current amounts and conditions of dead wood in the region.

"The range of ownerships and management objectives represented within the plot data indicate how forest composition, structure, and management history affect dead wood resources. We use the data from plots in forest stands that were never harvested to estimate the current range of natural conditions of dead wood," says Ohmann. In westside forests, these unharvested plots provide a proxy measure of historical range of variability of dead wood. However, this comparison cannot be drawn for east-side forests that have missed one or several fire cycles owing to fire exclusion.

"In compiling the plot data, we were careful to summarize the data in ways that were compatible with the wildlife studies, to aid eventual comparison" she adds.

Bruce Marcot

Piles of bark and debris at the base of snags provide dark and damp habitat for snakes, salamanders, and other wildlife.

Bruce Marcot

Down wood can persist on the forest floor for decades acting as a time-release capsule of humus and nutrients to the soil.

The wildlife data within DecAID Advisor was assembled from independent studies spanning several decades. Finding consistent measures of wildlife-habitat relationships required intense screening and data-mining. Kim Mellen, a wildlife ecologist at the Forest Service Pacific Northwest Region in Portland, led the effort to summarize the data. "Assembling the wildlife information took several years. We used journal articles, dissertations, unpublished data sets, and expert panels. There was a lot of winnowing of studies that used methodologies that, despite our best efforts, simply could not conform to the rest of the data. Once all the data were assembled, we had them peer-reviewed by dozens of wildlife experts," explains Marcot. "The process itself was an argument in favor of standardized research methodologies so that future researchers can compare across studies."

"The database clearly shows areas of greatest data gaps and greatest scientific uncertainty, such as in postfire conditions and quantitative use of decayed wood by invertebrates. This can help prioritize future research," says Marcot. Still, DecAID Advisor is the most comprehensive database on wildlife relationships with decayed wood ever assembled. DecAID Advisor is essentially a meta-analysis of such data and studies that were previously disconnected and incompatible.

Not surprisingly, DecAID Advisor immediately proved useful. According to Marcot and Ohmann, past tools for estimating dead wood and setting guidelines for wood retention after timber harvest were often based on theory, professional judgment, modeling assumptions, or, at best, limited empirical data. The statistical synthesis in DecAID Advisor corroborated suspicions that many of these early estimates grossly underestimated snag densities and down wood amounts used by wildlife or that would be found in unharvested forests.

Several Forest Service timber sales have been appealed on grounds related to dead wood standards for wildlife. "DecAID Advisor is now used by the Forest Service and others as an objective source of the most recent scientific information to set guidelines and assess wildlife needs. It is a major leap over past approaches," says Ohmann.

Science Findings is online at:

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

The site includes **Science Update**—scientific knowledge for pressing decisions about controversial natural resource and environmental issues.

DECISION AID, NOT DECISIONMAKER

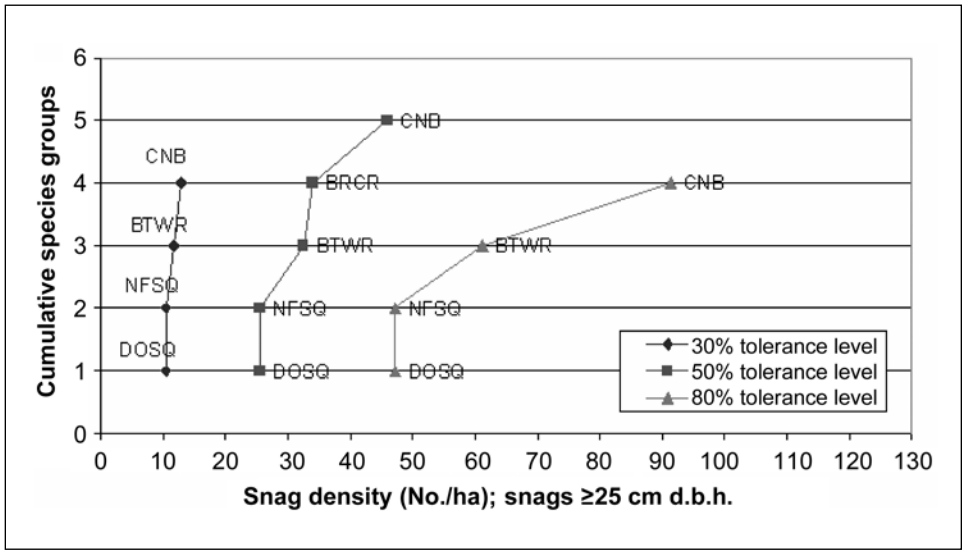
One primary difference between so called "managed" and "natural" forests is the removal of trees for timber harvest. Therefore, managed forests typically have less dead wood than do natural forests. That is not necessarily a good thing or a bad thing. How much dead wood is needed in a managed forest depends on the landowner's objectives and is mostly within the domain of the forest manager.

DecAID Advisor is, indeed, merely an advisor; it will not do the manager's job. It will, however, make their job a bit easier. For one, DecAID Advisor displays wildlife and inventory results in the form of "tolerance levels." Tolerance levels are akin to confidence levels and probabilities, but with some subtle differences.

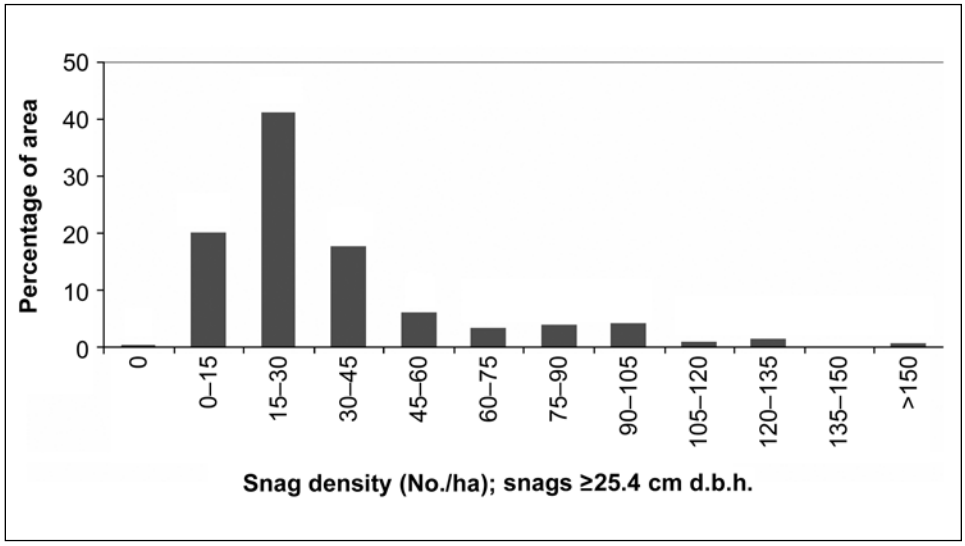
"From the wildlife side, tolerance levels are estimates of the percent of all individuals in a wildlife population that have been observed, in field studies, using various sizes or amounts of decayed wood, such as snags or down logs. We calculated three tolerance levels (30, 50, and 80 percent) for the size and density of snags and down wood used by wildlife species," explains Marcot, "but, if needed, the user can calculate other levels from the data presented in DecAID Advisor, too." The forest manager can use these tolerance levels to conduct a risk analysis, such as determining what population levels a given snag or down wood size or amount would provide, and how alternative management guidelines for decayed wood could provide for other population levels.

Let's again use the red-breasted nuthatch as an example: If a forest planner wanted to ensure that, after logging, there are sufficiently large snags to provide for nuthatch nest sites, DecAID Advisor could be consulted to see that 70 percent of nuthatch nests reported in the literature were in snags larger than 18 inches, 50 percent of nests were in snags larger than 31 inches, and 20 percent were in snags larger than 50 inches. Now, armed with that information, the planner can make decisions regarding snag retention and have a pretty good idea how well the landscape will provide for nuthatch nest sites.

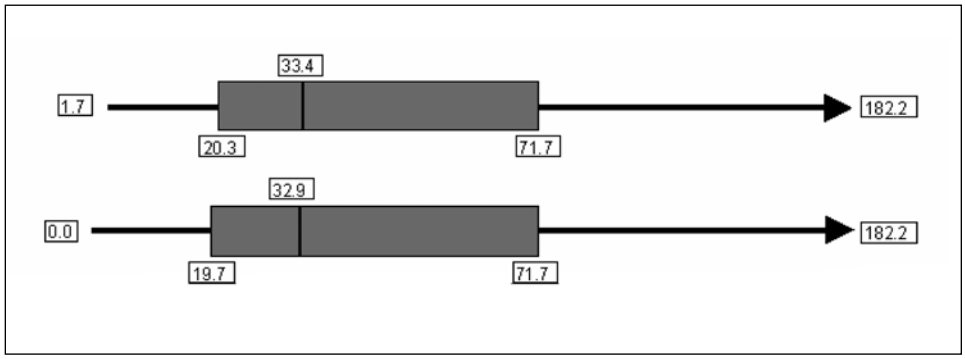
Tolerance levels are given for much of the data within DecAID Advisor, including the inventory plot information. Thus, DecAID Advisor can be queried to see, for example, that 50 percent of the unharvested forest in the Oregon Coast Range, west-side lowland conifer-hardwood forest in the larger trees structural condition contains more than seven snags per acre larger than 20 inches, whereas 20 percent have more than 12 snags



DecAID Advisor uses cumulative species curves to indicate the level of dead wood used by several wildlife species at three different tolerance levels. Here, the four letter codes refer to wildlife species (e.g., BRCR = brown creeper) and their placement indicates the density of snags that the species has been found in. D.b.h. = diameter at breast height.



To estimate historical levels of dead wood, DecAID Advisor uses unharvested inventory plots.



DecAID allows users to query dead wood levels taken from hundreds of forest inventory plots in Washington and Oregon. Here, the range of densities, along with 30, 50, and 80 percent tolerance levels of snags greater than 10 inches, is given.

per acre. This type of information lets landowners see how their land fits into the larger landscape, with regard to dead wood.

Each forest manager and wildlife biologist may use DecAID Advisor for a unique problem, and sometimes tolerance levels will not be enough. Never fear, DecAID Advisor has loads more information.

"For each wildlife-habitat type, DecAID Advisor first presents a narrative summary on wildlife, forest inventory, insects, pathogens, fungi, and other aspects of wood decay elements and their management considerations. From there, the user can drill-down to further levels to view data summaries, detailed data tables, and literature citations," says Marcot.

LAND MANAGEMENT IMPLICATIONS

- DecAID Advisor is used by USDA Forest Service Pacific Northwest Regional Office and national forests, and by other agencies and landowners, for helping guide management of snags, down wood, and wood decay elements.
- DecAID Advisor is a compilation of the best available science. Its application can help ensure use of best available science for decayed wood management. In turn, this means that decisions are defensible to help meet regulations requiring best available science.
- Under the new National Forest Management Act Planning Regulations, DecAID Advisor can help managers set desired conditions for decayed and dead wood habitat, in a repeatable, consistent procedure.

DEAD WOOD IN CONTEXT OF SPACE AND TIME

When it comes to dead wood dynamics, like most things in ecology, variation is the norm. One size, or amount, of snags and down wood does not fit all uses by all wildlife species in all forest types. Further, "the size and density of snags and down wood vary widely over space and time. As such, the appropriate geographic scale for using information within DecAID Advisor is the watershed, province, or large administrative unit such as a national forest or Bureau of Land Management district, certainly not the individual stand," says Ohmann. "When DecAID Advisor says a region has, on average, 12 snags per acre, that represents the aggregation over a large area that probably has dense pockets of snags resulting from fire or disease, and other areas where snags are rare."

Meeting objectives for wood decay elements at these broader scales can be difficult and DecAID Advisor can't do everything. It does not model stand growth or landscape dynamics, nor does it simulate snag or down wood recruitment or assess wildlife population viability. To plan for dead wood over time, the manager may need to link to other models of stand growth and disturbance dynamics.

"The overall lesson is that forest ecosystem managers can now view dead wood as a natural and desirable part of the forest, and more than just snags for woodpeckers," says Marcot. "Managing for all types of woody decay elements will provide for important functions for plants, animals, and ecological processes that together maintain natural, diverse and self-sustaining forests."

"DecAID Advisor is the first decision-aiding tool of its kind, given its scope of wildlife species, inventory data, and topics provided. We hope it will help managers who want to use the best information possible when planning for the future of dead wood in their forest," adds Ohmann.

"From my rotting body, flowers shall grow and I am in them and that is eternity."

—Edvard Munch

FOR FURTHER READING

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