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PNW
Pacific Northwest Research Station

Science FINDINGS

INSIDE

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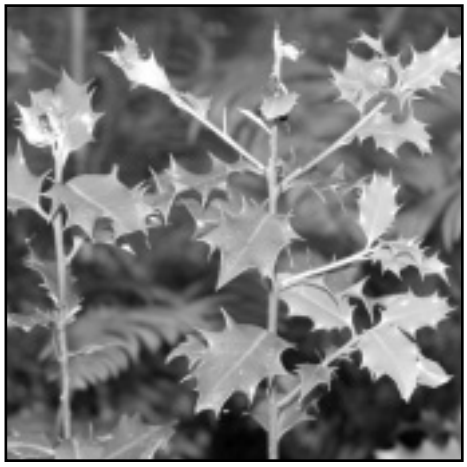
"Science affects the way we think together."
Lewis Thomas

INVASION OF THE EXOTICS: THE SIEGE OF WESTERN WASHINGTON

English ivy is spreading throughout forests in the Puget Trough, and even large, dominant trees within the forest are not immune from their stranglehold.



Holly is becoming widespread throughout forest understories in the Puget Trough, crowding out native, less aggressive species.

Described by some as a form of biological pollution, these species have been introduced—sometimes by accident, but often with the best intentions—into systems where they thrive at the expense of native species.

Oregon's Living Landscape, 1998

The golden blaze of glory that lights the freeway in the spring... Admit it, you've admired the showy blooming of Scot's broom on your journey along I-5. You might even have caught the smell if you were game to wind down the window.

Yes, it lights the freeway, but it also blights the forest. Introduced as an ornamental plant and planted to beautify median strips, this well-known shrub now threatens some parts of Washington and Oregon with its own pretty form of biological desert.

It is not alone. Weedy exotics such as English ivy, Himalayan blackberry, holly, sweet cherry, and many others are spreading through forests at rates that are alarming forest ecologists.

"Initially, none of them appeared to be a big problem, but the trend is certainly alarming," says Andrew Carey, a research biologist with the Pacific Northwest Research Station in Olympia, Washington. "Simplification of ecosystems and introduction of new species is helping to globalize world flora, endanger indigenous species—especially those with narrow habitats—and restrict ecosystem functions."

IN SUMMARY

Settlement of the Pacific Northwest by immigrants from the Eastern United States changed the composition of lowland landscapes from dominance by forests and prairie to dominance by cities, suburbs, agriculture, and transportation infrastructure. Historical disturbance regimes imposed by nature and by indigenous people were disrupted. In the uplands, timber management activities replaced natural disturbance regimes, often with simplifying effects on ecosystems. People intentionally and unintentionally imported exotic species of plants and animals.

Simplification of ecosystems and introduction of new species are contributing to globalization of world flora, endangering indigenous species, and reducing ecosystem function. Some permanent changes have been wrought; reversal of other changes and maintaining indigenous flora and fauna will require purposeful management.

Globalization of flora is the process by which certain aggressive species tend to dominate plant communities throughout the world, particularly where human activities are making conditions more conducive to invasion than they are naturally, he explains. Carey has observed that where natural resources are managed in a homogeneous way, such as in plantation forestry or row-cropping, the propagules of aggressive weedy species become so pervasive that they can move even into suboptimal sites.

"Some permanent changes have been wrought where local environmental conditions have favored them," he says. "It will take purposeful management to reverse less permanent changes and maintain indigenous flora and fauna."

KEY FINDINGS

- Studies of soil seed banks in young, closed-canopy, second-growth forests revealed that 30 percent of all species were weedy exotics, only 24 percent were natives, and no tree species were present. Thinning these stands could favor exotic species.
- Many of the small mammal communities in uniform second-growth stands are incomplete and differ in structure from communities in naturally young- or old-growth stands.
- Variable-density thinning has the potential to increase species richness within a short timeframe, provided it is used in a holistic approach that includes biological legacies, long rotations, and tree species diversity.
- Exotics may have altered the fuel environment in white oak forests sufficiently to pose a threat even to large-diameter oaks. Further, western gray squirrels have dramatically declined in these ecosystems in the last 10 years.

THE MAN-MADE HERITAGE IN FORESTS

In both Oregon and Washington, many low- to mid-elevation forested landscapes are dominated by even-aged, young forests of a single species, often Douglas-fir. These landscapes are typically clearcut descendants.

Shifts in thinking about past management are coinciding with increases in human population, decreases in timber harvesting, and concerns about sustainability of managed forests, Carey notes.

"Past management often simplified forest composition and structure," Carey explains. "Clearcutting, burning, planting of genetically uniform trees, application of herbicides, and precommercial thinning have diverted many ecosystem resources to rapid growth of timber and fiber. Fewer resources were intentionally directed to maintaining biodiversity."

After decades of this approach, one of the most apparent effects is the invasion by exotics, which are attracted, opportunistically, to areas of low competition and wide open spaces. They have the ability to respond rapidly, invade rapidly, occupy sites for a long time, and survive in poor conditions.

Natives with small, particular niches beware.

Nonetheless, Carey believes that appropriate management intervention can help these uniform second-growth forests move toward various late-successional goals, including the pivotal one of complexity of understory. Many silvicultural tools are now available to managers for such purposes: various harvest systems, retention levels and patterns, regeneration methods, and rotation lengths.

Carey is involved with three sets of large-scale experiments examining the developmental effects of exotic species on ecosystem function in western Washington; he emphasizes that the problem is certainly not limited to his own state. The three different studies have involved three different forest types, and have all raised similar concerns.

Scot's broom, originally brought in to beautify roadsides, readily invades newly disturbed areas.

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SOIL SEED BANKING ON THE OLYMPIC PENINSULA

In the early stages of stand development, coniferous forests of the coastal Pacific Northwest commonly pass through a period of dense shade and intense competition. During this phase, the abundance and diversity of understory plants decline dramatically.

This closed-canopy stage represents a critical juncture in the development of the forest understory. Canopy closure may result in the local extinction of some forest species and thus shape longer term patterns of understory composition and diversity, Carey explains.

A prevailing theory is that thinning dense young forests will help stimulate the suppressed understory. But the mechanisms by which understory species persist or reestablish are poorly understood. A cooperative study with Carey and Connie Harrington, a research forester at the PNW Research Station, Charles Halpern, a research associate professor at the University of Washington, and others from the university examined the potential contribution of the bank of seeds retained in the soil. The Olympic Peninsula was selected for its extreme tree densities and light exclusion during early forest regeneration in this wet and productive climate.

"Germination of buried viable seeds is likely to be stimulated by the abrupt increases in light produced by thinning," Carey says. "To what degree this promotes desirable species—such as shade-tolerant, native herbs, shrubs and trees—or encourages the germination of exotic species, depends in part on the composition of the seed bank."

The researchers investigated which species were present in the understory seed bank, and in what relative abundances. They also looked at how the litter layer seeds differed from that of the mineral soil and how seed bank composition differed among different parts of the forest.

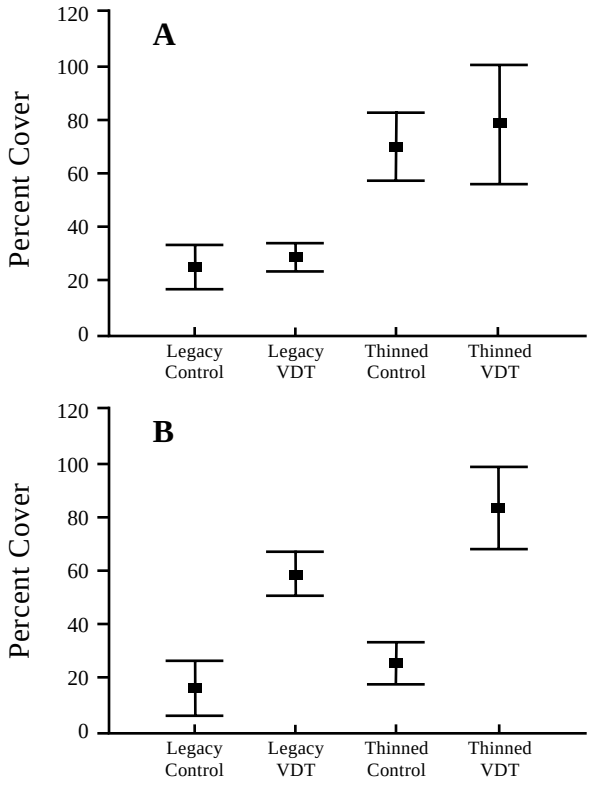
In an area where increasing attention is being given to the concept of restoring native understory vegetation via the soil seed bank, the news is not good. In the seed banks of 40- to 60-year-old unthinned, closed-canopy stands, 30 percent of all species were weedy exotics, only 24 percent were typical understory species, and tree species were absent.

"It has been hypothesized that the soil seed bank may provide one source of propagules for recruitment of forest understory species, but our results suggest otherwise: silvicultural thinning will result in limited germination of forest species but will often favor recruitment of exotic species," Carey says. "Moreover, retrospective studies of understory response to thinning suggest that some of these weedy species may be able to persist for decades following treatment."

LAND MANAGEMENT IMPLICATIONS

- Invasion by exotics and globalization of flora is a real and present problem, requiring thoughtful landscape-level planning.
- Management of forests that includes a mix of tree densities at the appropriate scales may help maintain indigenous species and the natural heritage of people in the Pacific Northwest.
- Novel management techniques will be needed for restoration of extirpated indigenous species to second-growth forest.

DOUGLAS-FIR FOREST IN THE PUGET TROUGH



Total plant cover in second-growth, Douglas-fir forests in the Puget Trough: never-thinned stands with old-growth legacies (Legacy Controls), legacy stands 3 years after treatment with variable-density thinning (Legacy VDT), conventionally thinned stands (Thinned Control), and thinned stands 3 years after VDT treatment (Thinned VDT).

A = native species

B = exotic species

WRITER'S PROFILE

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BAD NEWS FOR SMALL MAMMALS

That's not all. Carey notes that many of the small mammal communities in 37 second-growth forests studied were incomplete and differed in structure from communities in both naturally young stands and old growth. "Simplification of forest structure and composition has had negative consequences on small mammals and, presumably, on numerous ecosystem processes," he says.

Small mammal communities have potential as indicators of healthy forest floor function because they disseminate seeds, spores, and propagules of shrubs, bryophytes, fungi, and lichens, Carey explains. They also physically mix the soil, decomposed organic matter and litter, regulate some invertebrate populations, and provide prey for terrestrial and bird predators.

Not enough attention has been paid to the amounts of understory needed to maintain various food pathways for small mammals because understory development is often simply a by-product of management for high-quality timber. But Carey and others have produced some preliminary studies suggesting that plant species composition and spatial arrangements of plants are important to small mammal communities.

Hence, the arrival and spread of exotics, often to the exclusion of natives, augurs badly for creatures such as Trowbridge's shrew, red-backed and creeping voles, the deer mouse, and the montane and vagrant shrews.

Unlike natural upland disturbances, such as wildfire, windthrow, flooding, or the sustainable Native American burning practices, management of second-growth forests more often produces simplified and homogeneous environments. By reducing food pathways and ecosystem resilience, by opening the door to invasion by exotics, such management may reduce small mammal populations, in turn reducing their ability to support predator populations.

In the white oak forests of the Puget Trough area, the results for the western gray squirrel may be terminal.

BROOM AND DOOM IN THE PUGET TROUGH?

In the Puget Trough, the combination of annual burning by Native Americans, mild climate, and diverse landforms has led to some unique plant associations. These included Oregon white oak savannas, woodlands, and forests—a dynamic, shifting mosaic of diverse plant communities. But then came European settlement, grazing animals, particularly sheep, and human development, complete with transportation networks, agriculture, towns, and cities in the lowlands.

"Today, the citizens of Washington are in danger of losing a significant part of their remaining natural heritage—the legacies of the Vashon glaciation," Carey says. "Scot's broom has invaded wetlands and oak-dominated sites, and Douglas-fir is encroaching as well. Most notably at risk to loss are the Oregon white oak, the western gray squirrel, Roy's pocket gopher, a trillium, and a butterfly." Unless oak habitat is actively maintained, it will be replaced by a natural Douglas-fir succession, he adds.

The past 6 years has seen a rapid decline of western gray squirrel numbers on Fort Lewis Military Reservation, home to one of the largest remaining tracts of oak woodlands. Factors potentially responsible for the decline include poor acorn crops, drought, motor vehicle impacts, competition with the eastern gray squirrel, and reduction in quality and quantity of habitat, disease, and predation.

"Habitat fragmentation is an all-too-common problem for threatened species because many exist in isolated populations that are increasingly vulnerable to random events like genetic, demographic, and environmental uncertainties, and natural catastrophes," he says. "The occurrence of such unpredictable events can have potentially devastating effects when population numbers decrease below a minimum threshold."

Recommendations for enhancing the western gray squirrel's chances of survival? Foresters could remove excessive Douglas-fir to reduce competition with oak seedlings.

But exotic plant species are not so easily removed. Already, about 30 percent of species found in oak woodlands are exotics. Carey notes that Scot's broom may have altered the fuel environment in oak woodlands sufficiently to pose a threat even to large-diameter oaks, thereby suggesting a need for manual broom control before prescribed burning around oaks. Travel corridors between oak habitat areas, with improved water sources, may help the western gray squirrel persist in viable numbers.

"Currently management is not effectively addressing issues of decreasing land area available for natural communities, maintenance of landscape processes such as dispersal and colonization by western gray squirrels, landscape dynamics, or general values of the oak savanna mosaic," he says. "Such issues transcend any one management group and require both community and landscape management."

VARIABLE-DENSITY THINNING: DELIBERATE FRAGMENTS

In the millions of acres of second-growth forests in the Pacific Northwest, how might we encourage development of an ecosystem that is less vulnerable to exotic invasion and more inviting to the small mammal populations it has historically supported?

One of the more promising tools for achieving the biocomplexity typical of old forests that is so notably lacking in multiple-rotation forests, is variable-density thinning. Thinning to various densities, with corresponding differences in canopy cover, creates a mosaic of patches. According to Carey, such a mosaic has been hypothesized to promote processes associated with natural development of widely varying plant associations and foliage heights, along with horizontal vegetation patchiness. Effects on soil and vertebrate communities follow.

Carey and others established an experiment in Douglas-fir forests in the Puget Trough to determine the response of small mammal populations to vegetation changes induced by variable-density thinning during the first 4 years following experimental treatment. They treated stands that had been conventionally thinned as well as stands that had been protected from disturbance.

Stands that had been thinned twice with conventional commercial thinning had 94 species of vascular plants, twice that in unthinned forest. Eighteen exotic species were found in thinned forest, and none in unthinned forest. "Neither thinned nor unthinned second-growth supported complete small mammal communities or abundant small mammal populations, thereby suggesting both types of stands were on developmental tracks deleterious to indigenous species," Carey notes.

Three years after treatment, mosaics created by variable-density thinning had significantly greater plant species richness and greater herb cover than controls. The variable approach initially resulted in increased importance of 11 exotic species, decreased importance of 2 native species, and increased importance of 20 native species, including two kinds of trees. Furthermore, within 3 years, species richness overall increased by over 150 percent, and small mammals, rodents, and winter birds were showing positive responses.

"Our experiment, fully replicated, seems to be the first to evaluate the efficacy of inducing a mix of tree densities to influence positively a carefully chosen array of life forms," Carey says. "The changes we observed in the understory plant community following variable-density thinning, as compared to those following conventional thinning, seem to better mimic natural gap formation and promote variety in understory development."

Could it be that certain tenets of conservation biology need to be revisited and better evaluated?

RESERVES VERSUS TRUE COMPLEXITY

We have learned through recent experiments, Carey believes, that biological reserves are not sufficient to preserve complexity. In fact, because not every reserve will contain all the pieces of a working forest, or all the elements of randomness inherent in a dynamic system, a reserve is more likely to become more homogeneous over time with the loss of pioneer species like Douglas-fir, even if it does persist for 500 years, he says.

"The need to manage forests in their dynamic entirety across whole landscapes is becoming increasingly obvious, and until we learn how to do management well, set-asides should be seen as useful interim measures, not solutions in themselves," he says. Further, he adds, the concept of "matrix" areas as the leftovers that can be treated badly is a denigrating notion that does not value the whole forest.

"I have a visceral negative reaction to polarized adversarial relations and false dichotomies, such as timber versus wildlife, matrix versus preserve, and jobs versus owls. It frames arguments in very unproductive ways, and precludes useful solutions," says Carey.

Carey suggests that the reason variable-density thinning produces better all-round responses in forest values is that conventional thinnings are specifically designed to meet goals aimed at timber production, with little thought to biocomplexity. In fact, he notes, it has been found that even spacing of trees might have negative effects on spotted owl prey, fail to provide for the biotic integrity of small-mammal communities, decrease the abundance of amphibians, and lead to homogenization and globalization of understory flora.

But as with every "solution" that's offered, Carey reminds us, variable-density thinning needs a carefully planned context to succeed in multiple-value management. "It should be used in a management system that includes retaining biological legacies of large, live and dead trees, coarse woody debris, and intact patches of forest; managing decadence; promoting tree species diversity; and rotations longer than 130 years. Variable-density thinning should not be standardized for systematic application; the approach must be tailored to the site to achieve biocomplexity and biodiversity goals."

Perhaps the invasion by exotics will draw attention to yet one more aspect of the supreme value of complexity in a healthy forest, Carey says. Just like the complexity he prefers in an argument, biocomplexity is known to offer a broader variety of outcomes and a more dependable resilience.

The spread of exotic species has emerged in recent years as one of the most serious threats to biodiversity, undermining the ecological integrity of many native habitats.

Oregon's Living Landscape, 1998

FOR FURTHER READING

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