Pacific Northwest Research Station

Science Update

INVASIVE PLANTS IN 21st CENTURY LANDSCAPES

Tom Iraci

IN SUMMARY

A plant species is defined as invasive if it is non-native to the ecosystem under consideration, **and** if it causes or is likely to cause economic or environmental harm or harm to human health. Nonnative plant invasions are generally considered to have reached the Pacific Northwest in the mid-1800s with the arrival of European-American settlers. Invasive species such as sulfur cinquefoil, spotted knapweed, yellow starthistle, cheatgrass, and Japanese knotweed can displace native plants, disrupt ecosystems, affect biological diversity, increase soil erosion, reduce water quality, and change natural fire regimes. These and other invasive plants affect ecosystems from arid grasslands to forests,wetlands, and streams.

Nonnative plant species have become a significant component of forests across Oregon. At least one nonnative species was found on 70 percent of forested plots surveyed across Oregon. However, results differed with forest type; 100 percent of plots in juniper stands and 23 percent of plots in high-elevation conifer stands had at least one nonnative species. In 1 out of 10 forested plots, the nonnatives made up 20 percent or more of the total plant cover.

Scientists at the USDA Forest Service Pacific Northwest (PNW) Research Station, with management partners and other scientists, are working on a variety of studies related to invasive plant issues. They are developing reliable detection and inventory techniques, integrating species biology and invasion ecology, and identifying what makes habitats vulnerable and invasive plants so successful. They are integrating their research on control methods with work on habitat restoration and resilience of native plant communities. See inside for more on invasive plant scientific studies integrated within a management context.

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What are invasive plants and why are they a problem?

Plant species migrate naturally across continents, reach islands through seed drift, and shift their ranges as ice ages come and go. Ecosystems are adapted to the slow, natural movement of species as well as to the dynamics of wildfires, floods, and droughts. In the last several centuries, however, people have been able to travel between continents faster and easier than ever before and people have carried plants to places they would never have reached by natural dispersal. Once there, some nonnative plants escape the parasites, grazers, and other ecological controls of their home continent and become invasive.

In the Pacific Northwest, nonnative plant invasions are generally considered to have started in the mid-1800s with the arrival of European-American settlers. Catherine Parks, research plant pathologist at USDA Forest Service Pacific Northwest (PNW) Research Station, explains how a few of the invasive species got here. “Spotted knapweed came in the 1800s as a contaminant in alfalfa seeds, and yellow starthistle got here in the 1920s, also as a contaminant in alfalfa. Japanese knotweed was brought in deliberately as an ornamental. Cheatgrass seeds were in soil used as ballast in ships; one of the earliest infestations was near St. Louis, along the Missouri River.”

These and other invasive plants spread across cultivated and natural areas, along the Nation’s developing railroad system, through livestock grazing historically in far greater numbers than today, and eventually along 20th-century highways and as accidental passengers on jet planes and motor vehicles.

“Nonnative plants are any plant species that have been purposely or accidentally introduced into a region,” explains Andrew Gray, research ecologist for PNW Research Station.

Purpose of PNW Science Update

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But most nonnative plants don’t become invasive—apple trees growing by old homesteads and naturalized daffodils cause little ecological damage.

Yellow starthistle crowds out native plants such as this mariposa lily.

Key Findings

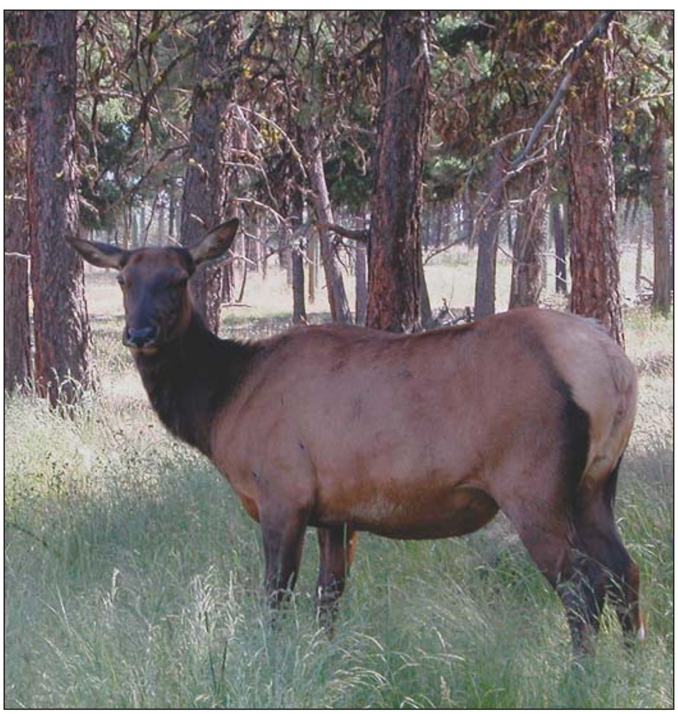
- Nonnative plant species have become a significant component of forests across Oregon. At least one nonnative species was found on 70 percent of surveyed forested plots across Oregon. Results differed with forest type; 100 percent of plots in juniper stands and 23 percent of plots in high-elevation conifer stands had at least one nonnative species.
- Nonnative species were significantly more abundant in stands with the smallest and youngest trees, and in stands with fewer overstory trees, such as stands recently thinned. This trend held for different forest types.
- Sulfur cinquefoil, an invasive plant in the Blue Mountains, may succeed by prolific seed production that swamps local seed banks, allowing it to form dense populations and crowd out native vegetation.
- Natural-color aerial photography, one of the least expensive remote sensing techniques, can be used to identify sulfur cinquefoil infestations in open forests and rangelands, even at low densities.
- One model for an effective invasive plant research program is the regional research program on sulfur cinquefoil. This program integrates experiments from the species level to the landscape level, includes multiple factors such as land use changes and ecological processes, and involves researchers and managers around the region in a problem-solving network.

The U.S. Department of Agriculture defines a species as invasive if it is nonnative to the ecosystem under consideration, **and** if its introduction causes or is likely to cause economic or environmental harm or harm to human health.

Invasive plants are spreading rapidly, and in some cases exponentially, across North America.

Many effects are harmful. Yellow starthistle is poisonous to some animals, unpalatable to others, and its inch-long, sharp spines make yellow starthistle stands nearly impossible for animals or people to even walk through—and yellow starthistle is growing on hundreds of thousands of acres in southeastern Washington and northeastern Oregon, with a major infestation in Hells Canyon, Idaho. Spotted knapweed displaces native rangeland plants eaten by wildlife and livestock and reduces native plant biodiversity. Cheatgrass displaces native bunchgrasses and dies early in the summer, thus reducing forage quality and increasing the spread and severity of fires, enough so that cheatgrass may modify fire regimes in some areas. Japanese knotweed can displace native plants along streamsides, producing cascading effects on the many animals that depend on these habitats and even affecting food chains in the streams.

In short, invasive plants can affect biological diversity, ecological processes, and land management in ecosystems from arid grasslands to wetlands and streams. Invasive plants are spreading rapidly, and in some cases exponentially, across North America.



Frant Vanni

Invasive plants reduce forage for wildlife from ground squirrels to elk, thus disrupting food webs. The effects cascade throughout ecosystems.

How widespread are invasive plants in the Pacific Northwest?

Over 3,000 species of nonnative plants have been identified in the United States; of this total, about 400 species are considered invasive plants. Invasive plants are estimated to cover about 133 million acres nationwide, and are expanding at the rate of about 1.7 million acres per year.

An excellent source of data on invasive plants in the Pacific Northwest is the Forest Inventory and Analysis (FIA) Program of PNW Research Station. The FIA Program has inventoried the Pacific Coast States since the 1930s. In the early years, inventory focused on trees as a timber resource. Over the decades, the FIA mission expanded to collect data on dead trees as well as live trees, and on understory vegetation, down woody material, lichens, and damage from insects, diseases, and ozone. The databases now have detailed information on many characteristics of Western forests and can be used to understand trends and develop projections of how these forests will change.

"The FIA inventory plots are a uniform grid across all the forests of a state," says Gray. The inventories use repeatable survey techniques on all lands so that results are statistically rigorous and representative of the forests in an entire state. Techniques have been modified several times over the decades. Since 2000, the FIA Program has collected the same data in the same way on all forest lands of all ownerships, with one-tenth of the plots in each state inventoried each year.

Over time, with comprehensive FIA databases, the trends in nonnative plants could be related to forest stand structure and management history.

The surveys began to inventory the most abundant understory plants in the late 1970s, and the information collected has become more detailed since then. On a subset of plots, called "forest health" plots, botanists record all species found. To inventory nonnative and native plants, Gray worked with Dave Azuma, research forester, to evaluate new monitoring protocols for the forest health plots and test them for statistical rigor. They used Oregon forests for their pilot project.

Azuma explains, "The pilot was set up to examine the feasibility and repeatability of more complete surveys of understory vegetation, including nonnative plants. Our reports for western and eastern Oregon showed the numbers of acres where nonnative plants were present. The additional information on the native plants and the forest structure on the plot helps us understand what kinds of forests are being invaded."

Their pilot study found that rigorous surveys of nonnative plants on forest health plots are feasible and repeatable. If

Inventory data for FIA are collected systematically throughout all forests, and the data can show trends in the spread of nonnative plants.

Japanese knotweed thrives in riparian areas such as this beach near Sitka in southeast Alaska, diminishing the diversity of native riparian plant communities.

surveys of nonnative plants become a regular component of the ongoing FIA Program, the pilot study data will develop into a more comprehensive database that reveals trends. Over time, with comprehensive FIA databases, the trends in nonnative plants could be related to forest stand structure and management history. The scientists would also be able to say which native plants used to be in those forest areas but are now missing or less abundant, and which plant associations are most affected.

Gray's and Azuma's pilot study found that nonnative plant species have become a significant component of forests across Oregon. At least one nonnative species was found on 70 percent of forested plots across Oregon. However, results differed with forest type; 100 percent of plots in juniper stands and 23 percent of plots in high-elevation conifer stands had at least one nonnative species. Nonnatives were a significant proportion of plant cover in juniper and many ponderosa pine stands, and made up 20 percent or more of the total plant cover in 1 out of 10 forested plots. Proportions of nonnative plants were highest in the Willamette Valley, Blue Mountains, and basin and range ecoregions. (The FIA plots are only on forest lands and not on agricultural, unwooded range, and other lands without forests.)

Nonnative species were significantly more abundant in stands with the smallest and youngest trees, and in stands with fewer overstory trees, such as stands recently thinned. This trend held for different forest types. Although these more open stands appear to have the most potential for displacement of native plants, some shade-tolerant, evergreen, nonnative shrubs, such as English ivy and English holly, may also have high potential to spread. High-elevation plots had fewer nonnative species, but this trend may reflect the proximity of low-elevation plots to nonnative plants in valleys rather than any constraints of higher elevation climate.

In western Oregon forests, the most prevalent nonnative species was Himalayan blackberry, followed by common velvetgrass, St. Johnswort, and cutleaf blackberry. Nonnative plants were almost twice as abundant on forest lands in the Willamette Valley ecoregion as in the rest of western Oregon.

In eastern Oregon forests, the most prevalent nonnative species by far was cheatgrass, followed by jagged chickweed, spring draba, and yellow salsify. Nonnative plants were more abundant in the Blue Mountains and basin and range ecoregions than in the rest of eastern Oregon.

For the state of Washington, comparable results should be available in late 2005. No comparable FIA statistics exist yet for Alaska, but other surveys have found that invasive plants in Alaska include Canada thistle, white sweetclover, Japanese knotweed, and bird vetch. White sweetclover now dominates the lower reaches of the Stikine River in southeast Alaska, is spreading on the Matanuska River flood plain in south-central Alaska, and has been detected on the flood plain of the Nenana River in interior Alaska. Sweetclover may outcompete native willows, important browse for moose, on the flood plains, possibly creating a serious shortage of winter food for the animals.

Coordinators of invasive plant programs plan to use the plant survey results from the forest health plots as the "information backbone" to guide intensive surveys, and they are looking for ways to collect additional data on new nonnative plants. The techniques evaluated in the Oregon pilot study will be phased in nationally over the next few years.

How can science help with invasive plant problems?

The USDA Forest Service's national strategic goal for invasive plants (and all invasive species) is stated in a 2004 report:

> *"Reduce, minimize, or eliminate the potential for introduction, establishment, spread, and impact of invasive species across all landscapes and ownerships."*

The national plan then lists four intermediate strategies for invasive plants: **prevention, early detection and rapid response, control and management, and rehabilitation and restoration.**

Parks sees an important role for research in all of these strategies. "We need all kinds of scientists," she comments. "We need to look at the watersheds and what we're losing in a more integrated way—how is the hydrology changed, the soil, the ecology. All the scales are important, and we need several different types of methodologies. The FIA Program is certainly one of those."

Here are some ways that research can contribute to the four invasive plant strategies.

Prevention. Clearly, prevention is the least expensive and most effective way to manage invasive plants. Research can develop new information about how to close and manage invasion pathways, how the invasive processes work, how to assess the risk of a new nonnative species becoming invasive, and the benefits vs. the costs of various preventive activities. Research can contribute information on best practices to minimize invasive risks in road maintenance, recreation, range management, prescribed fire, thinning, wildlife habitat improvement, and timber management.

Parks comments, "So far, ecologists are only able to provide after-the-fact explanations for invasions. Predicting which species will be invasive and their rate of spread and which habitats and ecosystems are vulnerable remains difficult."

Without a source of native seeds or a restoration strategy, treated areas are recolonized by invasive plants.

Early detection and rapid response. It would be desirable, obviously, to detect and stop invasive plants while their populations are small. Extensive ground surveys are prohibitively expensive. Research can assist in developing accurate, cost-effective ways to detect and inventory invasive plants. Remote sensing, which includes techniques from aerial photography to satellite imagery, is a promising area. Effective monitoring of invasive species will also require reliable, powerful, and cost-effective methods.

Control and management. Control strategies aimed only at destroying invasive plants have often failed. Herbicides, prescribed fire, and other methods kill weeds, but without a source of native seeds or a long-term strategy for restoration, the treated areas are recolonized by the same species or by other, potentially more damaging, invasive plants.

Science can contribute at all scales. At the species level, scientists can study the life histories and ecology of invasive species, and the suitability and risks of biological controls such as insects or fungi. At the habitat level, scientists can determine how habitat characteristics influence the success or failure of invasions. The environmental factors most relevant in plant invasions are usually soil, climate, and land use. Invading species themselves sometimes modify habitat,

Steps of the Plant Invasion Process

Introduction. Small populations of a new, nonnative plant are often undetected at first. The new species and its seeds compete with the native, well-adapted plants, and few introduced plant species go on to the next step. Nonnatives that do become invasive typically grow in small, isolated populations for several decades before they begin any major expansions. Control is least expensive at this stage, of course, and eradication may be possible. But detection is difficult, and if the new species is detected, the fact that it's not causing problems generally makes it a low priority for control. At this point, it is difficult to determine which introduced species are likely to become invasive.

Colonization or naturalization. At some point, for unknown reasons, established nonnative populations that covered only small patches, sometimes for years, begin to spread rapidly. The rate of colonization is closely related to the intrinsic, biological rate of spread for the species, with the invasive plants often taking advantage of disturbances such as fires, livestock grazing, timber management, and roads. A species usually invades a region with climate similar to its native range at first and then adapts to other climates over time. The landscape mosaic of forests, grasslands, fields, and towns, and the connecting corridors such as roads and rivers, influence the spread of the plant. Detection of established populations and control programs usually begin during the explosive spread phase.

Stabilization. Theoretically, an invasive plant will reach a threshold where its population stabilizes or at least slows down significantly, controlled by the availability of habitat, competition, or similar factors. Colonization or naturalization is complete at this point. Stable populations are seed sources for small, satellite populations that may become new infestations. Eradication of the species is probably impossible at this point, although biological controls might be able to reduce the dominance of some invasive plants in some habitats.

An integrated research program includes not only studies on ways to kill invasive plants, but also ways to establish a resilient native plant community again.

creating more favorable conditions for their continued growth and spread.

At the landscape level, scientists can learn more about the relations among plant invasions and fire, fuel treatments, grazing, and postfire restoration. The timing and intensity of prescribed burns, for example, is often critical, as native and invasive plant species have widely varying responses to fire. All of the species-, habitat-, and landscape-scale information is critical for building risk assessments that predict where a species might become established, which habitats are most vulnerable to invasions, and what factors influence their vulnerability.

Scientists can contribute to control work through research on the effectiveness and costs of biological, chemical, and physical control strategies. Effects on nontarget plant species are also important. Biological methods are pathogens and insects that affect the invasive plants or grazing with goats that eat invasive plants; chemical methods are the various herbicides; cultural methods include mulching and planting or seeding with competitive plants; and physical methods include hand pulling, cutting, and other mechanical treatments.

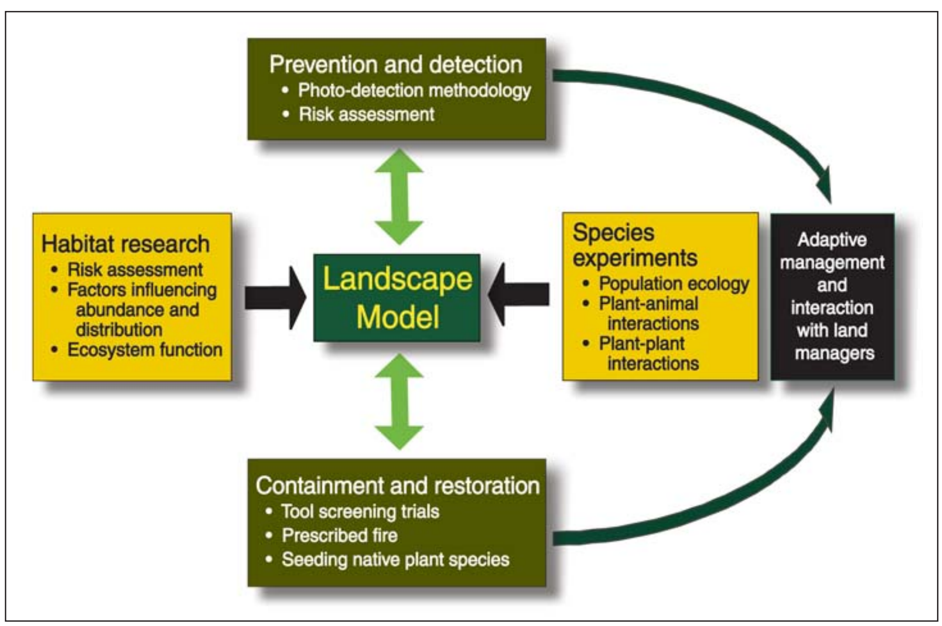
Given the complexity of controlling invasive plants, integrated management is promising, and the most useful studies evaluate well-planned combinations of these methods, applied and evaluated over ecologically meaningful periods. Cost-benefit analyses for treatments require knowledge of the ecological, economic, health, and social effects of invasive plants, another area with knowledge gaps.

Rehabilitation and restoration. Parks points out that some areas need rehabilitation before restoration is possible. "Some sites are so degraded that the original native plant communities cannot reestablish themselves." In these areas, nonnative but noninvasive plants might be used to amend site conditions, serving as a nurse crop for native species.

Passive restoration relies on natural processes to restore native communities after invasive plants are treated. Parks points out, "Just spraying invasives, or just resting the land from grazing, doesn't mean the native plants will necessarily return. The soils are changed. The ecosystem is changed. It's not like firefighting, where the fire stays snuffed out. Invasives can come right back, the same ones or different species."

Active restoration involves seeding with desirable species and other practices to improve the diversity and productivity of native species. Currently, few studies define the costs, benefits, and probability of success of active and passive management approaches in the Pacific Northwest. "Ultimately, restoration may be our most effective preventive measure because native plant communities may be more robust and resistant to invasion," comments Parks.

Scientific research on invasive plants is most likely to be effective when the various studies needed are planned as parts of an integrated research program. Steven Radosevich, Bryan Endress (both with Oregon State University), and Parks have developed a framework for creating such a program (see figure and also the sulfur cinquefoil case study).

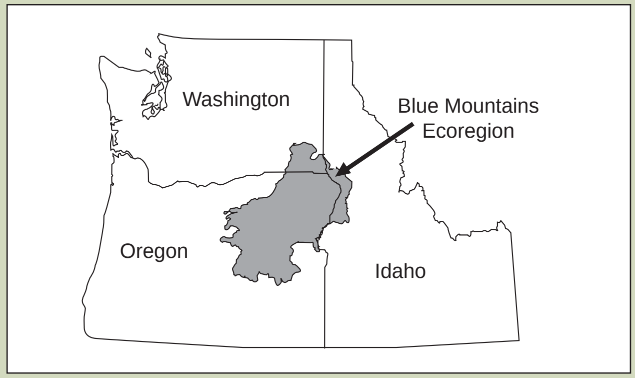


Radosevich, Endress, Parks

This framework shows the many individual parts of an integrated research program on an invasive plant species. The interrelated studies on sulfur cinquefoil (see case study) are an example of such a program underway.

Research Program Case Study: Sulfur Cinquefoil

Sulfur cinquefoil, native to Eurasia, was introduced to this continent before 1900 and is now found across North America, except in the Southwest. In Eastern States it is a minor agricultural weed, but in the dry climates of the interior Columbia basin, sulfur cinquefoil forms dense populations and is considered a threat to native plant communities. Sulfur cinquefoil appears to be displacing native grasses and forbs in grasslands and forest openings, although it remains unclear which species are directly at risk or which plant communities are most affected.



"It looks much like native cinquefoil species," Parks comments, "and so it often goes unnoticed." But sulfur cinquefoil, first reported in northeast Oregon in 1969, is developing into a serious problem. The dense populations have been most commonly found on disturbed soils such as old fields and roadsides, but they are now being observed on less disturbed rangelands and in the understory of open ponderosa pine forests throughout the Blue Mountains region (see map).

Frank Vanni

The yellow flowers of sulfur cinquefoil don't look threatening, but the nonnative plant is becoming widespread in the Blue Mountains ecoregion of Oregon, Idaho, and Washington.

"We're doing interrelated studies on sulfur cinquefoil," Parks says. The studies were designed from the beginning as a cohesive research program, and Parks points out that this approach is essential for effective research on invasive plant problems. One or two of the studies alone would offer little help.

Species-Level Experiments

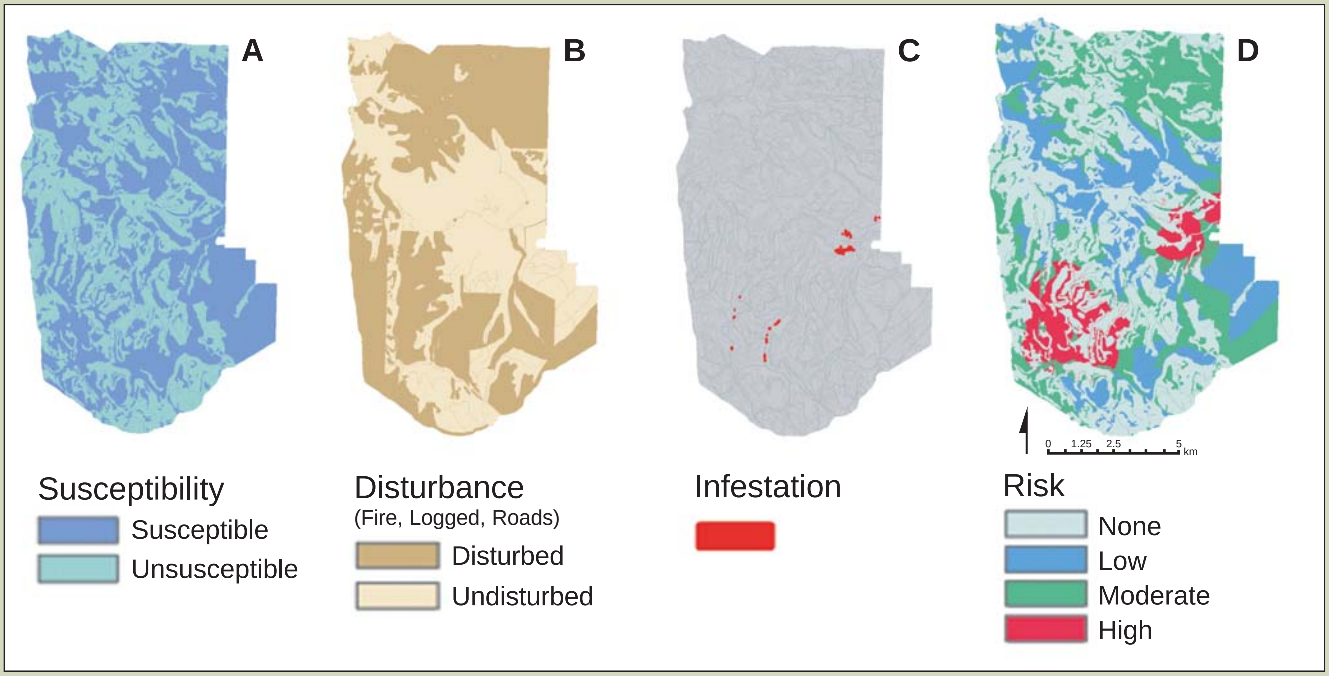
Species biology is basic to understanding the ecology of invasion and managing the invasion, but the biology is well known for only a few invasive plants in the interior Columbia basin, such as spotted knapweed, yellow starthistle, and leafy spurge.

Parks and other scientists have learned that sulfur cinquefoil's large, single taproots have annual growth rings, similar to tree rings, and sulfur cinquefoil plants in the Blue Mountains range from 1 to 10 years old, averaging 3.5 years.

Invasion ecology differs among invasive plant species. Sulfur cinquefoil grows at rates comparable to other common plants in the region, suggesting that this species does not invade by outgrowing native plants. The species reproduces only by seed, and its flowering, seed production, and seed dispersal biology do offer clues to its invasive success. Sulfur cinquefoil produces flowers with nectar richer in sugar and seedheads with twice the mass of native cinquefoil species. It produces seeds prolifically from July through mid-October, with an average 5,000 to 6,000 seeds per plant. Over 80 percent of the small, dark brown seeds drop to the ground within 2 feet of the mother plant, saturating the local seed bank.

This biology explains much about how sulfur cinquefoil is able to form very dense stands but does not explain how it is spreading so rapidly. Scientists are now investigating the roles of birds and mammals in dispersing the seeds. The seeds of other nonnative invasives (for example, leafy spurge and spotted knapweed) are usually viable after animals eat and later defecate the seeds; the seeds may even germinate better after their seed coats are scarified in the gut. Deer, elk, and cattle do browse sulfur cinquefoil seedheads in the fall, and studies are underway to determine if the seeds are viable after being defecated. Quail and turkeys are other possible seed-eaters. Seeds may be carried to new sites on animal hooves and fur, dirt on people's shoes, and mud on the tires of cars, trucks, and all-terrain vehicles. The seeds can remain viable in the soil for years.

Invasive plants compete with native species in various ways. Some species are not palatable to grazers (grazers include plant-eating insects as well as plant-eating mammals); others produce allelopathic chemicals (substances that inhibit other plants from growing); and most invasive plants are free from the parasites, predators, and diseases of their biological homes. Studies are underway to understand how sulfur cinquefoil is displacing native plants.



The GIS maps show the individual components that go into a risk assessment model including (a) habitats most at risk of sulfur cinquefoil invasions, (b) disturbance history, and (c) current sulfur cinquefoil infestations. The final, integrated map (d) shows that risk of sulfur cinquefoil invasion depends on the integration of habitat susceptibility, disturbance history, and proximity to current infestations.

One is a controlled experiment where various densities of sulfur cinquefoil, the native slender cinquefoil, and a native grass are planted alone and in mixtures, and the interactions among the three species observed. In a second study, different combinations of the three species are being planted in wet meadow, dry meadow, and open-canopy forests, at different elevations. The studies should yield results on competitive ability among the three species, and how the competition is affected by different site conditions. Another study is determining if deer, elk, and cattle graze on the plant foliage.

A risk assessment is a landscape model that predicts what areas or habitat types are most vulnerable to the invasion and spread of a particular invasive plant.

Habitat-Level Research

Parks and other scientists are also investigating which habitat factors enabled sulfur cinquefoil to spread across the Blue Mountains—soil types, land uses, associations with other plants, and any conditions where the plant flourished. One goal is to develop a risk assessment, a landscape model that predicts what areas or habitat types are most vulnerable to the invasion and spread of sulfur cinquefoil. A risk assessment has to include both species and habitat factors.

The risk assessment parameters were developed at the 28,000-acre Starkey Experimental Forest and Range, for use in the Blue Mountains. Geographic information systems (GIS) technology was used to integrate information on habitats most at risk of sulfur cinquefoil invasion, disturbance history (activities that disturb the soil or vegetation—livestock grazing, prescribed or natural fires, timber harvest, thinning, and roads), and the closeness of existing sulfur cinquefoil populations. The final map shows quite specifically which areas on Starkey are most at risk of sulfur cinquefoil invasion.

Management-Level Studies

The risk assessment is a tool designed to help managers, who consider all the dynamics going on in a landscape, including fire, land uses, ecological changes, grazing, streams, and road uses. Researchers are developing other tools for managers, intended to help with prevention, detection, control, and restoration.

Prevention and Detection

Early detection methods are enormously useful for managing invasive plants. Methods need to be accurate and cost effective for detection over large areas, so scientists are looking into remote sensing.

Bridgett Naylor, GIS analyst, with Parks and others, evaluated the effectiveness of natural-color aerial photography, one of the least expensive remote sensing techniques, as a tool for mapping sulfur cinquefoil infestations in the Blue Mountains. This particular species has distinctive, pale yellow flowers and a peak bloom period in early July, making it a good candidate for this technique. The work done so far indicates that natural-color aerial photography can be used to identify sulfur cinquefoil infestations in open forests and rangelands, even at low densities. Tree canopy cover hindered detection. The type of photographs needed are sometimes already available from aerial surveys done by state or federal agencies.

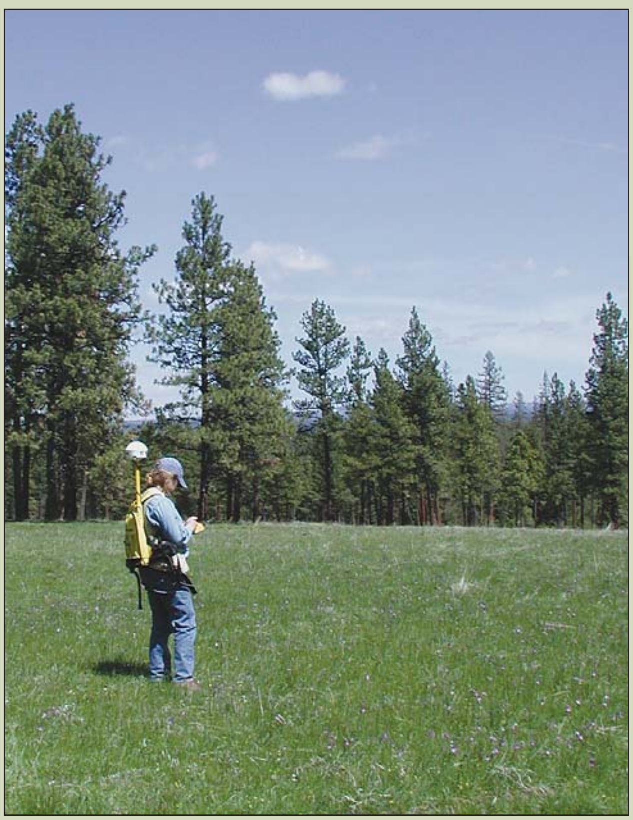
Containment and Restoration

The most valuable control strategy is likely to be an integrated approach that plans for habitat restoration and resilience of native plant communities as well as control of invasive species.

Burning and mowing have failed to displace sulfur cinquefoil. Herbicide trials are underway, where the type, rate, and timing of application are varied and effects on native and nonnative plant species closely monitored. The study is also experimenting with post-herbicide reseeding with a native grass seed mix; the effects on native and invasive species will be observed for several years.

Prescribed fire is being widely used to reduce fuels, but little is known about fire's effects on invasive and native plant communities. The sulfur cinquefoil research is testing the use of three prescribed fire treatments (spring burn, fall burn, and no burn), in combination with sowing a mix of six native grass species and use of the best-performing herbicide from the herbicide study. Researchers will monitor the abundance of native and invasive plants and species interactions on the grasslands for several years after the treatments. Biological controls are not promising for sulfur cinquefoil because they likely would affect closely related native cinquefoils.

Bridgett Naylor



Miles Hemstrom

Researcher with global positioning system unit compares field data on sulfur cinquefoil presence, percentage of cover, and stem density with estimates made from aerial photos.

Parks and the other scientists believe that research programs such as this one, which include coordinated studies of several factors, are more likely to produce results useful for managers. "Integrated experiments that combine invasive plant control with active restoration are likely to be more successful long term in creating sustainable plant communities," Parks comments.

Adaptive Management

The sulfur cinquefoil research program was designed from the beginning to examine the problem at scales ranging from the individual plant to a wide landscape, and including real-world dynamics such as fire, grazing, land use changes, and ecological changes. Each study was designed and carried out with many cooperators, including extension agents, the Oregon Department of Forestry, Oregon Department of Fish and Wildlife, Umatilla and Wallowa-Whitman National Forests, The Nature Conservancy, universities, Rocky Mountain Research Station, and private landowners.

Parks notes that the involvement of these partners strengthened the research framework and improved the results. She says, "This regional network of scientists and managers for the Blue Mountains ecoregion could be a prototype for an effective approach to invasive plant problems."

How can scientists and managers best work together on invasive plant problems?

Scientifically rigorous research can take a long time to accomplish and report, often too long for managers who must act quickly to prevent or contain the spread of an invasive plant species. Adaptive management, where research results are continually brought forward and management practices are continually reassessed as new information becomes available, may be the appropriate approach for invasive plant problems.

"A regional approach that places scientific study within a management context can result in more useful research results, and in greater management success in dealing with invasive plants," Parks says. In the cooperative sulfur cinquefoil program, managers tell scientists what they're doing and how well it works, scientists use that information in their research and develop new information, and managers use the new information to modify their actions. The feedback loop is quicker than has been typical in the management use of research results.

Looking around as well as looking ahead

Invasive plants have changed many ecosystems in Western States. They are a challenge where partnerships between managers and scientists can move both research and management forward.

In the Pacific Northwest, the most challenging invasive plant issues are in the drier climates of interior Oregon and Washington: the dry, low-elevation forests; woodlands; shrub-steppe lands; and grasslands. Riparian areas throughout the Pacific Northwest are often infested and are major corridors for invasive plants. In Alaska, invasive plant problems are most apparent in flood plains and riparian areas.

Invasive plants will shape our 21st-century landscapes.

At the species level, risk assessments, detection methods, and control methods could be used for high-concern species. Client input and a literature review suggest some high-concern species on forest lands:

- In the interior Pacific Northwest: Dalmatian toadflax, sulfur cinquefoil, knapweeds, yellow starthistle, nonnative hawkweeds, rush skeletonweed, and nonnative grasses such as cheatgrass and North African grass (ventenata).
- In riparian areas and other moist environments, both west of the Cascade crest and in Alaska: Japanese knotweed and white sweetclover.
- In southeastern Oregon riparian areas: tamarisk.

Bridgett Naylor

People have many questions to work on together in facing invasive plant problems: how to prevent new introductions, detect and quickly eradicate or contain new nonnatives, control and manage infestations, and restore native plant communities.

The ecology of many nonnative invasive plants is poorly understood, limiting the development of effective control methods.

At the molecular level, results from genetic research are beginning to identify genetic markers that clarify relations among species, identify which populations of native species would be most resilient to invasive plants, and clarify the risks of invasive plants hybridizing with native species, a suspected factor in the success of invasive plants.

At the landscape level, scientists are studying how invasive plants respond to disturbance and management, especially to wildfire, prescribed fire, fuel treatments, and grazing. They are also developing techniques to prevent invasions and build resilient native plant communities in rehabilitation and restoration projects, including postfire restoration.

The management of invasive plants and restoration of native plant communities will likely be integral parts of future land management.

"These plants will shape our 21st-century landscapes," Parks comments. "Before we can look ahead to controlling plant invasions, we have to look around and learn much more about ecosystems filled with native and nonnative plants."

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For Further Reading

Aitken, M.; Parks, C.G. 2004. Guide to the common Potentilla species of the Blue Mountains ecoregion. Gen. Tech. Rep. PNW-GTR-603. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 50 p.

Hemstrom, M.; Parks, C.G.; Kimberling, D.; DePuit, E.J. [N.d.]. Invasive plants in the Pacific Northwest: a problem analysis. Unpublished report, 68 p. On file with: USDA Forest Service, Pacific Northwest Research Station, P.O. Box 3890, Portland, OR 97208-3890.

Radosevich, S.R.; Endress, B.A.; Parks, C.G. [In press.] Defining a regional approach for invasive plant research and management. In: Inderjit, ed. Ecological and agricultural aspects of invasive plants. Basel, Switzerland: Birkhauser Verlag AG.

Resources on the Web

U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. http://www.fs.fed.us/pnw. This site accesses electronic information about PNW Station research, including invasive plant research. (1 February 2005).

U.S. federal government. http://www.invasivespecies.gov. This site is the gateway to national work concerning invasive species with links to agencies and organizations dealing with invasive species issues. (1 February 2005)

Mark Reid

Scientists and managers in the Blue Mountains ecoregion have developed a regional network to tackle invasive plant problems and actively restore native plant communities.

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Got Science?

The USDA Forest Service Pacific Northwest Research Station and other agencies are sponsoring two scientific conferences in the Portland area this spring.

Science and the Northwest Forest Plan: Knowledge Gained Over a Decade

April 19-20, 2005 • Jantzen Beach Doubletree Hotel • Portland, Oregon

For more information: http://outreach.cof.orst.edu/nwforestplan/index.php

This 2-day conference will share scientific information from the first decade under the Northwest Forest Plan, including monitoring data and research findings; the conference will also explore policy and management implications.

International Conference on Transfer of Forest Science Knowledge and Technology

May 11-13, 2005 • McMenamins Edgefield • Troutdale, Oregon

For more information: http://outreach.cof.orst.edu/fstransfer/index.php

This conference will present theories, methods, and case studies on ways that forest science organizations can encourage the use of their findings and innovations.