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Using Fire to Manage Invasive Vegetation: The State of the Art

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Fire Science Brief

RESEARCH SUPPORTING SOUND DECISIONS

Prescribed late spring burn of invasive medusahead at Bobcat Ranch, Yolo County, California. Credit: Joe DiTomaso.

Using Fire to Manage Invasive Vegetation: The State of the Art

Summary

People have used fire to manipulate the landscape since prehistoric times. The science of using prescribed fire to manage unwanted vegetation is a fairly new phenomenon, and it recently took an important stride forward. Researchers and land managers have compiled a synthesis of the most current knowledge of fire as a tool to manage non-native, invasive plants. The effort began in 2004 with a workshop where about 30 participants were invited to brainstorm the issues, assess the current state of knowledge, and establish the basic principles of the use of fire in the control of weeds. The findings were published as a peer-reviewed article aimed at the weed scientist community and as a handbook for land managers.

Much of the knowledge regarding the use of fire to control unwanted vegetation has been accumulated over time on agricultural lands. The purpose of this project was to make the information relevant to those who manage wildlands, where more complex objectives, including preserving or restoring native vegetation, are paramount. The comprehensive handbook provides wildland managers with the most current knowledge of the use of fire alone and as part of integrated strategies in the control of invasive species.

The handbook also addresses general issues such as safety, training of fire crews and managers, budget issues, public education, and responsibility and liability involved in planning and implementing prescribed burns, which are topics of interest to those using prescribed fire to achieve any goal.

Key Findings

- Fire alone rarely accomplishes long-term goals of suppressing invasive weeds and is most effective as part of an integrated strategy combining other control methods including, mechanical, cultural, and biologic tools.
- Repeated burning or intense fires can have negative effects on the land, but in general, careful use of fire can be less destructive than some other forms of control.
- Historically, much of the research on the use of fire to control invasives has been conducted on agricultural land and on just a few species. More research on the use of fire in wildlands is needed.
- Alternative control methods such as mowing, herbicides, and grazing can be used to manipulate the intensity of fire and optimize the positive effects of prescribed fire.

Spreading like wildfire

The direct and indirect damage that nonnative, invasive plants inflict on the environment can be hard to calculate. Cornell University researcher David Pimentel has proposed a conservative estimate of economic damages to the U.S. agricultural sector alone at about $27 billion per year, as measured by reductions in yield and costs associated with control. Invasive species are the top threat to biodiversity and ecological health in areas otherwise protected from development," says Doug Johnson, Executive Director of the California Invasive Plant Council.

Though fire has been used since prehistoric times to manage vegetation, the modern use of fire to control plants is an emerging science. Until recently, most studies on the use of fire as a management tool have been driven by requests for information from the agricultural sector and have been conducted on cropland and rangeland systems, primarily in western and midwestern states. Research on fire as a tool in managing wildlands has lagged behind, and the number of species studied compared to the multitude of species of concern is small. "In the past, most of the studies on fire in the control of invasive plants have come from agricultural crop settings, which are highly manipulated," says Matt Brooks, a Research Botanist with the U.S. Geological Survey Western Ecological Research Center. "Our ability to generalize that information to wildlands is limited."

Post-burn seeding plays a role in an integrated management strategy on agricultural lands. Bobcat Ranch, Yolo, California. Credit: Joe DiTomaso.

To begin to bridge that information gap, a workshop was held in 2004 with 30 participants representing research scientists and land managers from state and federal agencies and nonprofit organizations. These participants pooled their combined knowledge and personal expertise to find ways to transfer existing knowledge to wildland settings and to identify information gaps that need to be filled.

A synthesis of the published literature, "Control of Invasive Weeds with Prescribed Burning," was published in *Weed Technology* in 2006 and targets the weed scientist research community. This publication addressed the need for a comprehensive assessment of the science underpinning the use of fire to control invasive plants. It was an important step in advancing our scientific understanding, especially to influence the design of future studies in this field. However, "the *Weed Technology* publication was not ideally suited to address the needs of land managers, who generally need the salient points of scientific studies distilled into a more succinct practitioners' format," says Brooks.

To that end, the key investigators also created a handbook for land managers. The handbook, "Use of Fire as a Tool for Controlling Invasive Plants," outlines the basic principles of using fire to manage invasive plants, principles that can be adapted, with careful planning, to wildland situations. "It's important to exercise caution in extrapolating results of any study outside the study area that it was conducted. The guidelines in the handbook are designed to help in this process," says Brooks. In addition, because of the many variables that come into play with prescribed fire, including intensity, duration, weather, fuel loading, and moisture content, fire can have different effects at different times, even when applied in the same place.

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Support for this project came from the Center for Invasive Plant Management, the Joint Fire Science Program, and the U.S. Geological Survey. The California Invasive Plant Council (Cal-IPC) published the handbook, which is available online and in hardcopy from Cal-IPC.

Managing complex systems

Most agricultural systems are relatively simple compared to wildland ecosystems. In those settings fire is typically used to prepare the land for cultivation prior to planting or to remove waste vegetation such as stubble after harvest. The target plants are usually herbaceous, and the type of fire applied is relatively easy to contain.

Wildland systems are much more complex, with a variety of plant types: grasses, forbs, shrubs, and woody species. These systems also contain a complex mix of fuels, including fine and coarse debris, sometimes with dangerously high fuel loads that can carry fire into the canopy.

Both publications detail the major invasive vegetative types—annual grasses and forbs, biennial plants, perennial grasses and forbs, and woody species—and document each type's susceptibility to control by fire. In general, the research teams found that (1) in the western United States, annual species, both grasses and broadleaf, are most amenable to management with prescribed fire; (2) optimal timing for control of most invasive annuals is in spring or early summer, and this timing also may be most advantageous for native forbs; (3) prescribed fire is less effective in controlling biennials, though herbicide treatments can improve the effectiveness of the strategy; and (4) burning during the growing season rarely succeeds in woody species ecosystems, largely because of profuse resprouting from the rootstocks.

Both documents stress the importance of prescribed fire as part of integrated management strategies, for example using herbicide treatment before or after a burn, using fire to reduce dependency on herbicides, using well-timed mechanical treatments, and burning to prepare for a revegetation program or to enhance the efficacy of biocontrol agents such as insects that target invasives.

Fire can enhance effectiveness of insect biocontrol agents. Credit: Eric Coombs, Oregon Department of Agriculture, from insectimages.org.

The authors also outline strategies managers can use to manipulate the type and intensity of prescribed fire. On grazing lands, for example, if the fuel load is deemed insufficient to create a hot enough fire to destroy the target species, the fuel load can be allowed to build up by excluding livestock from the treatment area. Conversely, if the goal is a low intensity fire, the area can be grazed prior to the burn.

In addition to suppressing invasive species, precisely timed prescribed fire in the wildland setting can benefit desirable native plants present in the system or prepare a site for revegetative efforts. "The goal is not just to kill invasives, but to turn the system into a desirable one, whether to provide good forage for livestock or wildlife, promote high native diversity and rare and endangered species, or for recreational goals," says Joseph M. DiTomaso, cooperative extension specialist with the Weed Science Program at the University of California, Davis.

A key principle in controlling invasive plants with fire is to interrupt the reproductive cycle either by killing the target plant before it produces viable seeds or by destroying the seeds before they can germinate or disperse. "Timing is of the essence," says DiTomaso. "It can be difficult, however, to find the ideal moment to burn."

Timing is key to controlling plants and seeds. Medusahead seedheads killed by the heat of a prescribed burn. Credit: Joe DiTomaso.

To achieve the goal of controlling or eliminating invasive plants while doing as little harm as possible to desirable native plants, a working knowledge of the life history of the native and nonnative plants is essential. Consider the aggressively invasive yellow starthistle, one of the most serious threats to rangelands throughout most of the western United States. To destroy starthistle without ultimately harming native plants, the land manager needs to know the longevity of the seedbank for both native and nonnative plants. "If the seed of the desirable native plant has a 10-year longevity, and starthistle seed has a 3-year longevity, we can assume the native will rebound after the starthistle has been eliminated," says DiTomaso. "Some native legumes stay around for 50 years or more. If we deplete the starthistle seedbank, these natives will eventually recover."

The same consideration of seedbank longevity applies in integrated strategies as well, for example, using herbicides in conjunction with fire, as the native may be adversely affected in the short term, but rebound over a

longer time frame. This type of long-term information, however, can be difficult and expensive to document. Overall, researchers find that prescribed fire increases the diversity and richness of native species. "The most important piece of information the manager needs to know is under what conditions they can burn safely and not damage the native vegetation," says DiTomaso.

Since research has been conducted in limited habitats on a small number of species, DiTomaso cautions that land managers should use the handbook for general guidelines and learn as much as possible about the life cycle of the native and nonnative vegetation in their area.

In addition, DiTomaso notes that fire can be an inappropriate tool in some ecosystems, such as sensitive riparian zones that may contain native species not adapted to fire, or in the wildland/urban interface where smoke can adversely affect air quality or where public acceptance of controlled burning is low. In those cases mechanical or herbicide treatment may be preferred.

Air quality and road closures are a major public concern. Credit: Jennifer Chapman, National Park Service.

Another important consideration for the use of prescribed fire is understanding its effects on soils. With high-intensity fire or repeated fire, the most negative result can be erosion. It may be better to avoid fire altogether on steep slopes to minimize the risk of erosion. In fire-adapted systems, low-intensity fire and fast moving fire applied when the soil moisture is high can result in lower soil temperatures and less damage to soil chemistry. In determining a prescription for use of fire, the research shows that invasive plants themselves have adverse effects to the soil such as increasing the litter layer and increasing soil nitrogen. Carefully applied prescribed burn can reverse some of those effects with minimum adverse effects to the land compared to some alternatives.

Information gaps

In establishing the synthesis of known information, the research teams have identified a number of areas where further research is needed. One of the most important of these is documentation of fire characteristics during prescribed burns. "The characteristics of the fire need to be described as precisely as possible," says Brooks. "It's not enough to simply report results after a fire; fire crews and researchers need to quantify and report the characteristics of the fire as well." Burn crews can assist in this documentation by describing as many variables as possible, including the intensity, duration, timing, spread rate, and continuity of the fire. Other variables include weather, fuel loading, fuel on the ground, and soil moisture content. These variables can be evaluated ahead of time, improving the chances of achieving the objective of the burn. The intensity of fire, for example, can easily be measured by establishing temperature probes at critical places in the fuel bed.

Fire affects all components of soil. Chemical, biological and physical properties are all altered from heat and oxidation of fuels. Credit: Stephen Ausmus, USDA Agricultural Research Service.

DiTomaso cites the case of fire to control the invasive winter annual medusahead. In the 1960s, results of research on this aggressive species, which has invaded much of the Pacific Northwest, were mixed. By getting an approximate idea of the fuel load—clipping it beforehand, drying it, and weighing it—researchers were able to determine that successful suppression of the weed was directly related to a heavy fuel load that allowed a hot fire and long exposure to high temperatures. Such measurements are fairly easy and inexpensive to carry out.

Fuel loads, site, and weather conditions affect burns. Credit: Tim Bradley, National Park Service.

Vigilance is an ongoing battle

Nonnative plants have been arriving on the shores of the North American continent since the first explorers and settlers brought them, intentionally in the case of agriculture, erosion control, or forage species, or inadvertently, hitching a ride in cargo. Some begin to proliferate immediately; others lie in wait for years or decades to take off.

Yellow starthistle, for example, arrived via a circuitous route, likely from Eurasia to Spain, then on to Chile, and finally in the mid 19th century to the shores of California in a shipment of alfalfa seed. This invasive forb continues to spread, its seed carried on farm equipment, contaminated hay and soil, the fur of animals, and even people's boots.

In more recent years, invasive species have been introduced through the horticultural industry. With the increase in international trade and the challenges of climate change that may give invasive vegetation an edge, land managers face ongoing challenges in waging war on invasive species.

Brooks cites the need for land managers to be vigilant for nonnative vegetation that may be just beginning to make a toehold in the landscape. "If an invasive species is already widespread, it may not be one you want to spend your time on. It may be better to focus on controlling new invaders and small populations before they become big." Since invasive plants often begin their spread along road or water corridors or locally disturbed areas, immediate, focused action may stem their spread beyond the point of entry.

"The science of using prescribed fire as a management tool is maturing, adding a critical tool to the land manager's toolbox."

"We are facing a huge challenge with invasive, nonnative vegetation," says Cal-IPC's Doug Johnson, "but I remain optimistic. The science of using prescribed fire as a management tool is maturing, adding a critical tool to the land manager's toolbox."

Management Implications

- Fire is a tool that should be used in concert with other weed management strategies.
- At the time of prescribed fire, burn crews can help researchers by gathering essential data, at little cost or effort, about fire characteristics such as fuel load, flame length, fire intensity, rate of spread, fire duration, and duration of smoldering.
- Resource managers need a working knowledge of the local ecosystem and life history of invasive and native plants.
- If an invasive species is already well entrenched, managers need to prioritize, focusing on new invaders and small populations before they get out of control.

Further Information: Publications and Web Resources

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Scientist Profiles

Matthew L. Brooks earned his Ph.D in Biology from the University of California Riverside. He is currently a Research Botanist, and the Principal Investigator, at the USGS Western Ecological Research Center Yosemite Field Station. His research focuses on the ecology of fire and invasive plants in western North America, and on the effects of anthropogenic disturbance on ecosystems.

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