the cottonwood forests before a catastrophic fire occurs. However, we were concerned that methods traditionally used to kill monospecific stands, such as bulldozing or aerial herbicide spraying, would also destroy the cottonwoods. Since we could not find any documented case studies addressing this problem, we experimented with a variety of mechanical and herbicide treatments to remove the unwanted trees and control root sprouts without damaging stands of cottonwood.

In 1998, we contracted four tractors with front-mounted, flail-type mower heads that can mulch woody trunks and stems up to approximately 8 inches (20 cm) in diameter. We knew from our previous experience controlling saltcedar trees that it is difficult to effectively kill sprouts from large root crowns. Therefore, we decided to mow Russian olives that were less than 4 inches (10 cm) in diameter and remove larger trees with chainsaws.

From November 1998 through February 1999, crews cleared small-diameter Russian olives and woody debris from the site using the mulching tractors. At the same time, eight workers equipped with chainsaws and herbicide backpacks worked in the thinned-out stand to fell and treat larger Russian olive trees. Within five minutes after cutting each tree, they sprayed the cut-stump surface with a 50-percent solution of Garlon-4®. Next, they cut and removed usable firewood from the forest. The mulching tractors then made a second pass through the stand to pulverize the remaining tree waste.

By summer 1999, there were Russian olive root sprouts throughout the project site. Because Russian olive trees have long, shallow root systems, we could not determine conclusively whether the root sprouts were from the small-diameter trees that were mowed or from the larger trees that received cut-stump herbicide treatments. We observed very few root sprouts within a 10-foot (3-m) radius of sprayed stumps that were less than 8 inches in diameter. However, we found numerous root sprouts within close proximity of larger, sprayed stumps. This lead us to suspect that a 50-percent solution of Garlon-4® is not effective on Russian olive stumps that exceed 8 inches in diameter.

From June 15, 1999 through July 16, 1999, an eight-person ground crew used backpack spray units to apply a 25-percent solution of Garlon-4® to the leaves of Russian olive root sprouts. The following summer, root sprouts were substantially less prolific. We repeated identical herbicide applications (but with fewer workers) during a two-week period in early summer 2000, and again, during a five-day period in the summer of 2001. While sprouts of Russian olive are now under control, averaging less than three sprouts per acre, we will continue monitoring and applying herbicide to sprouts as they occur. During the first year of implementation, we spent approximately $1,632/acre ($4,031/ha) to control Russian olive. In 2000, we spent about $40/acre ($100/ha) to treat root sprouts and, in 2001, about $17/acre ($42.50/ha).

We have also experimented with other mechanical treatments in an effort to compare cost and project management efficiency. These include traditional logging equipment, such as log-loaders, and stationary grinders to remove and mulch Russian olive and saltcedar on a 450-acre (182-ha) site. We are also establishing experimental plots to test the effectiveness of various herbicides on Russian olive root-sprouts (McDaniel and others in press). Nonetheless, we believe that the methods described in this note can successfully control Russian olive in cottonwood gallery forests.

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Simple and Cost-Effective Methods Control Fountain Grass in Dry Forests (Hawaii)

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Fountain grass (*Pennisetum setaceum*), a highly invasive and fire-promoting species, poses the most serious threat to the restoration and preservation of native dry forest communities on the island of Hawaii. Originally introduced in the early 1900s, this drought-adapted perennial bunchgrass now dominates pastures, forest understories, and barren lava flows on the leeward side of the Big Island (Degener 1940, Wagner and others 1990). Our research has shown that fountain grass not only increases the frequency and intensity of fires, but also alters basic ecosystem properties such as light availability, soil water holding capacity, nutrient uptake, and various microclimatic variables (Cordell and others in review). We have found, however, that simple and relatively inexpensive techniques can both control fountain grass and facilitate the establishment of key native dry forest species (Cabin and others 2000).

In 1995 we implemented an aggressive fountain grass control program within the 6-acre (2.43-ha) Kaupulehu Dry Forest Preserve, an enclosed site on the leeward side of the island that has some of the highest quality dry forest habitat in the state (Allen 2000, Cabin and others 1999, 2000). Using weed whackers and multiple follow-up applications of Fusilade® at the manufacturer's recommended rate, we managed to reduce fountain grass cover from 90 percent cover to 10 percent after 10 months (Cabin and others 2000).

This technique is most effective during the active growth stage of fountain grass, which appears to be related to rainfall and is not necessarily seasonal. After cutting fountain grass with weed whackers, we wait for the grass to resprout before applying herbicide. We have found that three or four subsequent applications over a three to four month period are required to effectively eliminate any new growth. The herbicide treatment does not appear to damage native vegetation, although this has not been quantitatively tested. We have made several refinements that reduced our initial weed control effort from a cost of more than $5,000 per acre ($12,500/ha) to less than $800 per acre ($2,000/ha), including 1) replacing Fusilade® with a more cost-effective, glyphosate-based herbicide (Roundup® at a rate of 1.5-2 percent) and 2)

A student worker cuts fountain grass (*Pennisetum setaceum*) with a weed whacker before applying herbicide. *Photo by Susan Cordell*

purchasing our own weedwhackers, backpack sprayers, and other equipment rather than contracting out the work. This method has facilitated the natural regeneration of native species, such as ´aheahea (*Chenopodium oahuense*) and awikiwiki (*Canavalia hawaiiensis*), which had been suppressed by monocultures of fountain grass.

We continue to control fountain grass by spot herbicide application and/or hand pulling approximately two times each year. After five years, fountain grass no longer invades areas it once dominated. We are surprised by this result and at present do not understand the causal mechanism behind it. The low germination of seeds in soil that we removed from areas where fountain grass is abundant suggests that the spread of this species is potentially limited by seed viability (Sanford and Cordell unpublished data). Paradoxically, Goergen and Daehler (2001) have determined that seed production and seed viability of fountain grass is prolific relative to native grasses.

We are also pursuing other, possibly more cost-effective, methods for restoring larger tracts of invaded forest land. For example, we have recently found that bulldozing infested sites and suffocating fountain grass with plastic mulch may be viable approaches on certain sites (Cabin and others in press). In addition, we are currently working with the U.S. Fish and Wildlife Service to reduce roadside fuels and promote native plant restoration by embedding native plants within a matrix of 12 different fountain grass control treatments, including grazing, burning, herbicide application and various combinations of these three treatments. Results from this study may provide important information that will help us develop methods for restoring severely degraded landscapes on a much larger scale.

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Rensselaer Effort to "Pull Mussels" at Lake George Looks Promising. 2001. Anon. **ScienceDaily,** www.sciencedaily.com/releases/2001/06/010612070141.htm.

Rensselaer Polytechnic Institute (RPI) in Troy, New York, is attempting to reduce the number of zebra mussels (*Dreissena polymorpha*) in nearby Lake George by manually removing the mollusks. In spring 2000, divers pulled more than 19,000 zebra mussels from the lake. They have collected less than 400 mussels since April 2001, indicating that the technique is working. In addition, most of the mussels pulled in