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Aloha to Flammable Fountain Grass: Fuels Management Comes to the Big Island of Hawaii

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Joint Fire Science Program

Fire Science Brief

RESEARCH SUPPORTING SOUND DECISIONS

Prescribed fire burns through invasive fountain grass in Hawaii's lava beds. Credit: M. Castillo.

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Summary

Fountain grass is an invasive, highly flammable ornamental plant that has overtaken the dry, tropical ecosystems of west Hawaii. Over the last several decades, large, fast spreading fountain grass fires have burned across the landscape with increasing frequency, usually ignited by roadside activities in remote areas. The Pu'u Anahulu Fuels Management Project evaluated the effectiveness of different roadside fuels treatments on fountain grass using a collaborative approach, and allowed the first use of science-based fuels treatments and prescribed fire in Hawaii. Demonstration sites were established along roadsides where ignitions were known to occur. The clear winner for sustained reduction of fountain grass was a three stage application of prescribed fire, grazing and herbicide.

Key Findings

- The most dramatic and sustained reduction in fuel loads occurred on sites that received a combination of prescribed burning, cattle grazing and aerially applied herbicide.
- The most effective, immediate fuel load reduction treatment was prescribed fire alone. Repeated burning however may not be feasible for private landowners and ranchers due to the cost and complexity of conducting fires.
- Low-intensity grazing alone was not effective at reducing fountain grass.
- Herbicide (commercial Glyphosate 41 percent active ingredient) killed fountain grass and caused a gradual reduction in fountain grass fuel load, but released the predominantly non-native seed bank which included three plants that are toxic to livestock.
- The fountain grass seed bank is somewhat depleted by burning and can be maintained at low levels with herbicide.
- Well-managed rotational cattle grazing holds promise as a long-term sustainable fine fuels management technique where compatible with land management objectives.

Landscaping efforts feed flames

Contrary to the postcards, Hawaii's vegetation is not all dripping tropical foliage and lush flowering gardens. Much of the state is actually quite dry. Average annual rainfall on the island of Hawaii (the Big Island) ranges from over 235 inches on the windward side to less than 10 inches on the leeward side. The arid western regions are known as "Leeward Hawaii" and have historically been dominated by dry forests. Historic dry forest landscapes were expansive, particularly on the large islands of Maui and the Big Island. There is little agreement on the ecological role of wildfire in these areas, but in general the ecosystems and weather patterns lack the ingredients for frequent fire. There isn't much lightning, and most native trees and shrubs aren't structured for rapid regeneration after fire. Historically, fire has made only infrequent appearances on these islands—outside the flaming cauldrons of volcanoes.

Early in the 20th century however, the stage was set for fire to become a more common and problematic occurrence. In 1917, the owners of the Pu'u Waawaa Ranch on the Big Island imported fountain grass, an ornamental landscaping plant native to Mediterranean and North African coasts. Although introduced to beautify, its presence turned destructive over the following decades. Fountain grass is a water hog and it easily overcame native woody vegetation. It's now common on windward valley walls, sea cliffs, lava flows and roadsides. It has spread into the rangelands of Hawaii's cattle country where it is displacing more nutritious, introduced pasture grasses that already carry low intensity fire quite well. Fountain grass has compounded that flammability and established a strong foothold on the landscape.

By colonizing increasingly busy roadsides, the grass has delivered itself to the doorstep of one of the most available ignition sources in the state. The region's few highways wind through oceans of fountain grass that are easily ignited by a carelessly tossed cigarette or random spark. Fountain grass fires now burn every 8 years on average through ecosystems accustomed to almost no fire. With every fire, more native vegetation is lost while fountain grass expands. It now covers over 200 square miles of Leeward Hawaii. Only a handful of trees and shrubs remain, including many that are now endangered.

Fountain grass has taken over the landscape along the highways of Leeward Hawaii, where it is easily ignited by roadside activities. Credit: M. Castillo.

Fountain grass is a very common ornamental plant not just in Hawaii, but almost everywhere across North America. Mick Castillo can vouch for the popularity of the shiny, delicate looking grass, with its gossamer, celery green stems and silky seeded tops. Currently an ecologist with the Lower Rio Grande Valley National Wildlife Refuge in Alamo, Texas, he's seen it in plenty of places in addition to Hawaii, where he was a principle investigator on this project, along with David Weise of the USFS Pacific Southwest Research Station.

"It's also documented as an invasive in California, Oregon, Nevada, Colorado, Arizona, New Mexico, Louisiana, Florida, and Tennessee," Castillo says. "It's planted as an ornamental here in south Texas, and probably every state in the U.S. I expect it will continue to spread."

During the last twenty years, fountain grass fires have burned over 30,000 acres in Leeward Hawaii where insufficient fire fighting resources combine with rough terrain and rugged lava flows to make suppression difficult. These fires threaten communities, private property, public resources and infrastructure. They degrade watersheds, increase wind erosion and reduce cover for game animals

and rare species. With fountain grass and the wildland-urban interface expanding, highway traffic and wildfires increasing, and the native ecosystem disappearing, the time was right to bring science based fuels management to Hawaii—and the Pu'u Anahulu Fuel Management Project was born.

Fuels management new to Hawaii

In the years leading up to the project, considerable efforts had been put into restoring native dry land habitats to the region. But Castillo says no one had focused on the fuels management, which he and his colleagues recognized as a critical first step to meaningful, landscape scale restoration. Small scale attempts had been made by various entities to reduce fountain grass fuels using weed whackers and backpack sprayers. But Castillo is most impressed by the way Ranch Manager Mikio Kato managed fuel loads at the forty thousand acre Pu'u Wa'awa'a Ranch during the 25 year period preceding the study. Now retired, Kato used grazing methods that kept fires small and isolated, preserved existing forests and allowed forest regeneration in a few rested paddocks. "His approach cost him revenue because he kept stocking rates lower than his counterparts," says Castillo, "but he managed in harmony with that harsh landscape. He used rotational grazing to keep fire at bay, preserved the forest and paid the water bill all at the same time."

Kato understood the magnitude of the fountain grass fire issue better than most, as the grass had been introduced on his ranch over 50 years before he came on the job. He urged formal study of a wide range of treatments. No one had tried combining grazing and herbicide to combat the grass in Hawaii—and no one had used prescribed fire, much less combined it with other treatments. Isolated from the continental U.S., there were no Forest Service or Bureau of Land Management district offices to take the lead on prescribed burning. The U.S. Army had used prescribed fire on the island with varying success, but not for fountain grass control, and the already overstretched state forestry and wildlife programs didn't have experience applying the technique on State lands. Castillo and his collaborators wanted to introduce prescribed fire to the state, to see what it could do alone and in combination with other fuel reduction techniques.

Tailoring treatments for local needs

The study was funded by the Joint Fire Science Program (JFSP) as a demonstration project and initiated through a partnership between the Hawaii Division of Forestry and Wildlife and the U.S Fish and Wildlife Service Division of Ecological Services in Honolulu, where Castillo was based. The overall objective was to proactively manage wildfires by determining the best techniques for reducing roadside fountain grass through an unprecedented collaborative effort—directly involving all stakeholders in planning, research, implementation and monitoring.

It provided a place at the table for the different perspectives, experiences and goals of everyone involved—and in small island communities that means *everyone*. Project participants included several agencies and organizations, including local ranchers and the U.S Army. The effort provided the first opportunity to implement prescribed burns on state land, and to apply herbicide aerially for the purpose of managing wildfire fuels. The primary concern was to protect state game management areas, conservation zones and private ranches.

"Our intent was to have full landowner/operator and interagency participation," Castillo says. "This allowed us to apply the treatments at a larger scale—one that was practical, feasible and relevant to ranchers. We couldn't expect ranchers to take anything away from this if we did it in a lab, and we couldn't have little, one-square meter plots. That's just not practical for people dealing with hundreds or thousands of acres."

A sea of fountain grass glows in the Hawaiian sun while cattle graze in the study area adjacent to the ignition-prone Mamalahoa Highway. Credit: M. Castillo.

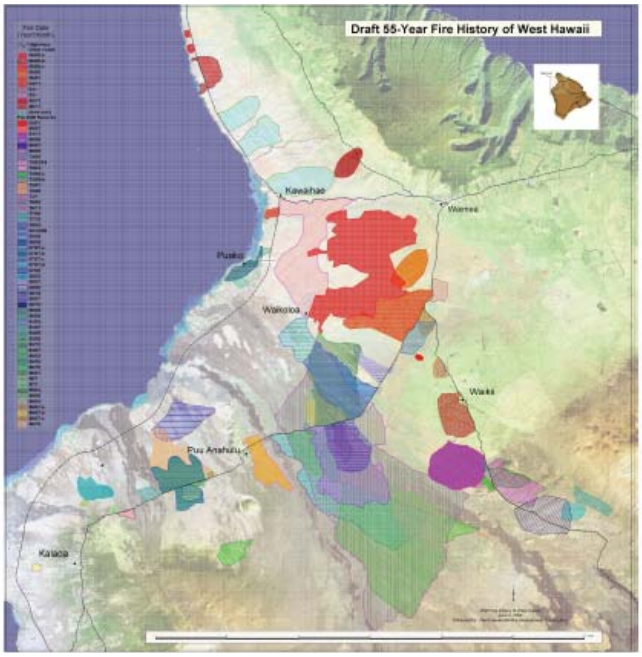
Hitting the highway

The first phase of the study analyzed previous fountain grass fires that had been mapped by a loose-knit group of firefighters and land managers who eventually formed the Hawaii Wildfire Management Organization (HWMO). Over the past 55 years, 68 fires had occurred that were classified as major incidents receiving multi-agency response. Collaboration with firefighting personnel revealed that over 95 percent of the fires were human caused and that half of the fires burned during the months of July, August and September. Their fire history map (on page 4) clearly showed that the majority of recent ignitions took place along the Mamalahoa Highway—the primary inland connection between the growing towns of Waimea and Kona. So that's where the treatments went—right in the middle of the historical ignitions where the project couldn't be missed by the locals.

"Putting these large treatment blocks right on the highway gave the project a lot of visibility," Castillo explains. "Most people on this rural island are tuned in to the landscape so they noticed. A lot of ranchers travel that road and we received a lot of supportive comments. They were able to see it all first hand and make their own assessment of what we were doing and why we were doing it."

The project evaluated eight separate, five acre treatments over a study area that measured one and a quarter miles long and a quarter mile deep along the most

ignition-prone stretch of the Mamalahoa. The project encompassed 240 acres of roadside fountain grass growing on and among lava flows that are thousands of years old. Four primary treatments were applied individually: spray, burn, graze and control. Combinations included burn/spray, graze/spray, burn/graze, and burn/graze/spray. Treatments were evaluated through periodic measurements and photo documentation over a two year period. Photos were taken each time the fuel load was sampled: pre-treatment, immediate post-treatment, four months, one year, and two years post-treatment. Effects of treatments on predicted fire behavior were modeled using observed fire behavior and measured fuel load data.



Map of the year, month and ignition point of fires that burned during the past 55 years. Treatments were located along the portion of the Mamalahoa Highway where most of the previous ignitions had occurred.

Aerial view of three different treatments. Credit: C. Dorn.

Triple treatment wins out

The most effective, immediate fuel load reduction treatment was prescribed fire alone. But sustaining the effect using fire alone would require repeated burns which may not be feasible for private landowners and ranchers due to the cost and complexity of burn operations. Herbicide alone was not as effective in immediately reducing fuel loads, however fuel decreased over time as the dead grass broke down into leaf litter and started to decompose. The treatment of cattle grazing alone was initially applied at intensity too low to appreciably reduce loading. However two additional short rotations immediately following the study demonstrated that repeated rotations with the same herd can result in reduced loading and gradual improvements in range condition. When grazing was applied following burning, cattle showed a clear preference for the greener forage which slowed grass regrowth in that treatment, but one to two years after grazing ceased grass fuel load returned to high levels.

As Castillo had anticipated, some form of combined treatment was necessary to effectively control the fountain grass over time. The most dramatic *and* sustained reduction in fuel loads occurred in sites that received a combination of prescribed burning, cattle grazing and herbicide, in that order. This was effective immediately, four months later, one year and two years later, and was significantly more effective than prescribed burning, grazing or herbicide alone.

Herbicide applied aerially was the final step of a three-phase treatment that provided the most sustained reduction in fuel loads. Credit: M. Castillo.

Toxic interlopers in the seed bank

Herbicide treatment killed the grass, which remained standing but gradually decreased in load throughout the first year. It also generated another significant effect that the other treatments didn't share: It allowed the dormant seeds of nearly two dozen new plant species to germinate. Regeneration following herbicide treatment brought three especially vigorous and problematic newcomers: Tree tobacco, castor bean and Madagascar ragwort, all of which are highly toxic to livestock. Castor bean appeared in older, volcanic soils in treatment areas that received herbicide only. Tree tobacco popped up in areas with younger soil that saw herbicide alone or in any combination. The Madagascar ragwort showed up wherever herbicide was applied regardless of substrate age. Castillo suspects that these weed responses have everything to do with water. "Fountain grass out-competes other plants because it is a superior competitor for water in this dry area," he explains. "When we killed the grass it freed up water so the pest plants finally had what they needed to get going. This water availability released the whole seed bank, not just these three species. We saw a lot of broadleaf exotics and basic pasture weeds that had accumulated in the soil over the years."

Pre-treatment surveys showed that the seed bank was dominated by non-native species. Of the 23 species that germinated only three were native. Fountain grass seeds were among three alien grass seeds found. Tests showed that if it is intense enough, heat from fire can kill fountain grass

seed, but Castillo suspects that the porous structure of the lava fields provides pockets of cool refuge for seeds during fire and that this is one of the mechanisms by which the grass persists.

Tobacco tree and Madagascar ragwort, both toxic to livestock, were among the plants that emerged after herbicide use. Credit: M. Castillo.

Synching fuels management with ranching culture

Each treatment and combination has its pros and cons depending on management objectives—which can differ significantly. From the ranching perspective, good forage must remain after treatments in order for the land to retain value. There must be enough grass to feed cattle but not enough to carry fire. From Castillo's perspective as an ecologist, the ideal scenario is different: He'd like to see all the invasive fuels eliminated and the sites restored to a native plant community that's not as flammable, but he understands that this clearly is not an option for ranchers. Ultimately, solutions have to work for the people who have owned and worked the land for a century. The collaborative nature of the project allowed for some middle ground. Castillo says that the goal of managing roadside fuels in a way that prevents ignitions can be achieved with either approach. The study demonstrated that when roadside pastures are well maintained, roadside ignitions are reduced.

But there's still a bit of a hurdle involving both agricultural tradition and economics. Since the first cattle arrived in Hawaii over two hundred years ago, ranchers have had very large pastures and taken a very hands-off management approach when it comes to grazing. But managing livestock as a component of fuels management is more intensive. Grazing pressure needs to be sufficiently high to achieve fuel reduction without overgrazing, and cattle have to be distributed somewhat evenly to make it work. In addition, grazing treatments have to be timed for periods of best utilization. This is a much more engaged and expensive approach that includes additional infrastructure specific to the task. Some ranchers just aren't willing to invest the time, energy, planning and money required. Castillo suggests compensating ranchers for these significant changes to traditional island practices, perhaps by eliminating grazing leases, providing supplemental feed or helping with infrastructure improvements.

Just the beginning

The methods developed by the study seem to be working for some landowners and the pay-off of fewer fires is motivating. At the conclusion of the study, two workshops were held that Castillo deems very successful—other than they seemed too short. "The morning discussions could have gone on all day," he says. "There were so many issues to talk about because this was the first opportunity for people to really sit down and have a discussion about fire. The ranchers really wanted to convey their perspectives on how the landscape had changed over the years, where the castor bean came from, and what it takes to successfully graze fountain grass."

The study area continues to serve as a demonstration site administered by the local Division of Forestry and Wildlife office and the HWMO. The HWMO has charged ahead with implementation of results by installing helicopter dip tanks and fencing, and helping landowners focus grazing on roadsides where ignitions occur. Further study is needed on several issues including the timing, intensity, and duration of grazing rotations, and the relative contributions of dead fountain grass and invading woody pest plants to fire hazard and behavior. In the mean time, Leeward Hawaii has a new suite of tools for limiting fire to its original place in the Hawaiian landscape—where everyone can agree it belongs—spewing from volcanoes.

Management Implications

- Prescribed burning alone is most effective for immediately reducing fountain grass fuel loads but effects are short-lived. Repeated burns may not be feasible for private landowners and ranchers because of cost and complexity.
- Aerially applied herbicide is effective in killing fountain grass and is very cost effective. Time is needed however to allow fuel loads to decrease. Dying grass contributes to fire hazard during this period.
- Fountain grass mortality caused by herbicide appeared to release the existing seed bank. This may result in establishment of other non-native and invasive species and require subsequent management depending on objectives.
- Grazing is practical and cost effective when applied at appropriate intensity and provides a mechanism for integrating fuels reduction with island-based agricultural practices.

Further Information: Publications and Web Resources

Project final report: http://www.firescience.gov/projects/01-3-2-14/project/01-3-2-14_final_report.pdf

23rd Tall Timbers Fire Ecology Conference Paper: http://www.fs.fed.us/psw/publications/weise/psw_2007_weise(castillo)003.pdf

Hawaii Fuels Photo Series:

Wright, C.S.; R.D. Ottmar, R.E. Vihnanek, D.R. Weise. 2002. Stereo photo series for quantifying natural fuels: grassland, shrubland, woodland, and forest types in Hawaii. *USDA Forest Service General Technical Report PNW-GTR-545*.

Hawaii Wildfire Management Organization:
http://hawaiiwildfire.org/aboutus.html

Scientist Profiles

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U.S. Forest Service, Pacific Southwest and Pacific Northwest Research Stations
State of Hawaii, Division of Forestry and Wildlife and Department of Highways
Hawaii Wildfire Management Organization
Hawaii County Departments of Fire, Civil Defense and Public Works
U.S.Army Pohakuloa Training Area
Hakalau Forest National Wildlife Refuge
Hawaii Volcanoes National Park
Pu'u Waawaa Cattle Company
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