Cooperative Extension Service
College of Tropical Agriculture and Human Resources
University of Hawai'i at Mānoa

Pasture and Range Management
Oct. 2005
PRM-1

Fireweed Control: An Adaptive Management Approach

Mark S. Thorne,[1] John S. Powley,[2] and Glen K. Fukumoto[3]
Department of Human Nutrition, Food and Animal Sciences
[1]Kamuela, [2]Kahului, and [3]Kona offices, UH-CTAHR Cooperative Extension Service

Fireweed (*Senecio madagascariensis* Poiret, also called Madagascar ragwort) is one of more than 1200 species of *Senecio* distributed throughout the world.(1) It is a native of Madagascar and South Africa(2) that became established in Hawai'i in the early 1980s. Fireweed seems to have first appeared in Hawai'i in pastures near Hāwī (North Kohala District, Hawai'i County).(3) Today the weed is widespread on the islands of Maui and Hawai'i, infesting vast acreages of pasture, rangeland, and roadsides (Figure 1). In some parts of those islands, up to 60 percent of the vegetative cover is fireweed. In such areas, forage production is estimated to be reduced by 30–40 percent.

Description

Fireweed is a low-growing, upright, branched herb that grows to between 4 and 20 inches tall, depending on the environment.(3) Fireweed's dark green leaves develop in an alternating pattern along the stem. They are often narrow and can be up to 2½ inches long, with edges that may be smooth, serrated, or lobed. Its composite flower heads, composed of both disc and ray florets, are grouped in flattened, terminal clusters. The showy yellow ray florets usually number 13 (Figure 2). Both disc and ray florets produce a seed. Each flower has greenish, overlapping bracts beneath the ray florets.

Fireweed has a dry, slender, cylindrical seed, called an achene, that is no more than 1⁄10 inch long. Each seed is tufted with white hairs that aid its dispersal by wind. Each flower can bear up to 150 seeds, and an individual plant can produce up to 30,000 seeds. Fireweed seeds remain viable for at least several years.(4) Thus even in areas with only a light infestation, as many as a million fireweed seeds can be present on or in the soil of an acre of pasture.

Fireweed is usually an annual, growing from seed, but under certain conditions the plants can reproduce vegetatively, taking on some characteristics of a short-lived perennial. When its stems are trampled and contact moist soil, roots and shoots can sprout from the stem's nodes, resulting in new, self-supporting plants. Fireweed's shallow taproot, highly branched with fibrous roots, and its slender stems contribute to the ease with which the plant can be laid over and produce stem sprouts (Figure 3).

Figure 1. A heavy fireweed infestation (> 30% cover) on rangeland in the Saddle Road area of the island of Hawai'i.

Figure 2. Fireweed flowers profusely, and each flower can produce up to 150 seeds, which are easily dispersed by wind.

Published by the College of Tropical Agriculture and Human Resources (CTAHR) and issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Andrew G. Hashimoto, Director/Dean, Cooperative Extension Service/CTAHR, University of Hawai'i at Mānoa, Honolulu, Hawai'i 96822. An equal opportunity/affirmative action institution providing programs and services to the people of Hawai'i without regard to race, sex, age, religion, color, national origin, ancestry, disability, marital status, arrest and court record, sexual orientation, or status as a covered veteran. CTAHR publications can be found on the Web site <http://www.ctahr.hawaii.edu/freepubs>.

Pyrrolizidine alkaloid poisoning

Of the more than 1200 different species of *Senecio*, only 25 are proven to be toxic to animals. Although evidence is limited, it is strongly suspected that *S. madagascariensis* may also be toxic to animals.

Most available information on the principal toxins in species of *Senecio* is from studies on tansy ragwort (*S. jacobaea*), threadleaf groundsel (*S. douglasii*), and Ridell's ragwort (*S. riddellii*), among others. The principal toxins in these species are compounds known as pyrrolizidine alkaloids (PAs).(1) PA concentrations vary with the species and their growth stages. In general, young pre-flowering plants are more toxic than older plants.

Figure 3. In some environments fireweed can function as a short-lived perennial. When stems are laid over and contact moist soil, new roots and shoots can sprout along the prostrate stem, resulting in a new, self-supporting plant.

Effect of PA poisoning on animals

A wide range of animal species shows susceptibility to PA poisoning. Agriculturally important animals in Hawai‘i, listed from most susceptible to least, include pigs, poultry, cattle, horses, goats, and sheep.(1) On an equivalent-weight basis, sheep can consume about 20 times more fireweed than it would take to poison a cow. The ability of sheep to tolerate PAs is primarily due to the presence of specialized rumen bacteria that detoxify the alkaloids before they are absorbed.

The following effects of PA poisoning were reported by Knight and Walter.(1) Lethal, acute poisoning occurred in cattle and horses consuming between 4 and 8 percent of their body weight in green tansy ragwort (*S. jacobaea*). Chronic poisoning led to death in as little as 4 weeks in cattle that consumed more than ⅓ lb of tansy ragwort (dry weight basis). Conversely, sheep and goats had to consume two or three times their body weight of tansy ragwort (green plant material) before a fatal poisoning developed. Goats fed 1 percent of their body weight per day of dry tansy ragwort aborted pregnancy, while the chronic lethal dose in goats was between 2.6 and 8.9 lb per pound of body weight.

In general, animals that have poor nutrition, are pregnant, or are experiencing other metabolic stresses are more susceptible to PA poisoning than animals in good health. Pyrrolizidine alkaloids are secreted in the milk of cows and goats and in low quantities can cause mild liver changes in calves and kids consuming the milk. There is no evidence that humans are adversely affected by consuming milk that contains PAs.(1) Likewise, these alkaloids do not accumulate in the muscle tissue of animals consuming plants that contain them.

Pyrrolizidine alkaloids are readily absorbed from the digestive tract of the animal and transported to the liver. Enzymes in the liver convert PAs to toxic pyrroles, which are the principal toxins causing liver cell damage.(1) The pyrroles biodegrade following reaction in the liver and thus do not accumulate in the animal. The greater the exposure of the liver to pyrroles, the more liver damage occurs. Animal death results from the loss of liver function. Secondary photosensitization often develops under chronic PA poisoning, when 80 percent or more of the liver has been destroyed, because the liver is no longer able to eliminate phylloerythrin, a bacterial breakdown product of chlorophyll.(1)

Signs of poisoning

Like other poisons, the degree to which signs of pyrrolizidine alkaloid poisoning are detectable depends on the amount of the poison in the animal, relative to its body weight. Acute poisoning, which occurs when animals ingest large quantities of forage that contains PAs, might only be detected after the death of the animal. Chronic poisoning, by and large the most common form of PA poisoning, can take several weeks to months before the animal begins to show symptoms. Again, these factors depend on the amount of forage consumed and length of time the animals are exposed to the forage. Common indicators of PA poisoning are

- Lethargy, loss of interest in food, and abdominal pain.
- Crustiness around the eyes and nose; the eyes may also be red and watery, especially in bright sunlight, a sign of secondary photosensitization.
- Animals may develop lesions; hair may slough from areas with light-pigmented skin (secondary photosensitization).
- Diarrhea or constipation.
- Weakness (wobbling and dragging rear feet).
- Animals may wander aimlessly and appear to be blind, and may become belligerent.
- Cattle may develop a pig-like odor that has a sweetish quality.
- The abdominal cavity may fill with fluid.

Hawai'i fireweed PA concentrations

In January 2005 a small-scale study of the PA concentration of Hawai'i fireweed plants was conducted. Plants were collected from the islands of Hawai'i and Maui. The plant samples were sent to the USDA Agricultural Research Service's Poisonous Plants Research Laboratory in Logan, Utah. The results showed that fireweed plants on the islands of Hawai'i and Maui contain 10 different PA compounds (Table 1). On the island of Hawai'i, there was a relationship between PA concentration and elevation, with the plant concentration of PAs greater at higher than at lower elevations. The causes of these elevational influences on PA concentration in fireweed are being investigated. The preliminary results suggest that fireweed growing above 3500 feet elevation will be more toxic than fireweed below this elevation, but further study is needed. An exception was the 6400 ft elevation on Mauna Kea, where the soil was less fertile than at the other locations (Table 1).

Pyrrolizidine alkaloid concentrations in fireweed plants collected on Maui were not correlated with elevation. Maui fireweed varied in PA concentration from a high of 1990 ppm to a low of 217 ppm. The reasons for this large difference in PA concentration are being investigated.

In comparison, PA concentrations in other species of *Senecio* known to be highly toxic to livestock ranged between 2000 and 180,000 ppm for Ridell's ragwort and 200 and 9000 ppm for tansy ragwort.[5] However, lethal concentrations for these two species were observed to be between 2000 and 45,000 ppm.[5] This suggests that fireweed in Hawai'i may not be nearly as toxic as other *Senecio* species. Nevertheless, it is important to remember that poisoning is a function of dose. Consumption of plants with even low concentrations of PA in large enough quantity will result in poisoning, possibly to the point of death.

Integrated fireweed management

Control of fireweed is important for several reasons:

- Potential toxicity to domestic livestock.
- Heavy infestations greatly reduce the productivity of grazing systems.
- Not doing anything will only compound the current infestation to greater proportions.
- There is a significant economic loss to the state through reduced carrying capacity of range and pasture lands, reduced livestock numbers, and poor animal condition.

Because of the prolific nature of fireweed (high seed production and viability, adaptability to varied environments) it is not likely that the weed will be eradicated in Hawai'i without substantial coordination and cooperation among federal, state, and county agencies and private land managers. Significant inputs of money and energy would be required to eradicate fireweed from Hawai'i's range and pasture lands. Because this level of involvement is not likely, control of fireweed becomes a management issue; that is, effort needs to be put toward managing the current level of infestation by preventing it from spreading to new lands and suppressing its impact on the range and pasture lands that it currently occupies. To do this, land managers need to plan, implement, follow through, and monitor their efforts.

Table 1. Pyrrolizidine alkaloid concentrations (ppm) in fireweed collected at five elevations on the island of Hawai'i.

	Elevation[1] (feet)				
	2500	3100	3500	4000	6400
Alkaloid					
Senecivernine	5	14	29	43	53
Senecionine	9	14	19	32	15
Integerrimine	6	7	7	11	10
Retrorsine	2	43	31	56	31
Usaramine	96	70	54	115	46
Unknown	4	16	3	21	4
Otosenine	36	429	264	678	71
Desacetyldoromine	24	38	117	55	92
Florosenine	193	121	679	167	153
Doronine	60	76	306	75	123
Total PA conc.	436	828	1508	1254	597
Soil total N (%)	0.98	2.40	3.30	1.32	0.51

[1]Concentrations of PA for elevations 2500 through 4000 feet are from plants collected in Pu'uwa'awa'a. Concentrations at 6400 feet are from plants collected on Mauna Kea. Concentrations are averages of 10 samples expressed in parts per million (ppm) of dry plant matter.

An adaptive management approach

For the successful control of fireweed, federal, state, county, and private land managers need to develop integrated weed management plans (IWMPs). In fact, these plans should be part of any management program for all land units in Hawai'i, even on lands without fireweed, as a preventive measure. When developing an IWMP, landowners and managers should include three measures or levels of activity:

- Prevention—Implement preventive measures to keep land free of fireweed where it is not currently established; this will greatly reduce weed control costs later.
- Control—Set priorities for control and elimination of fireweed where it is already established.
- Immediate response—Take prompt action when fireweed first appears.

Successful control of fireweed will depend on the degree of planning and the type of management actions implemented. Landowners and managers need to be able to adapt to the changing characteristics of fireweed infestations as the weeds grow, flower, seed, and spread from year to year. For this reason, landowners and managers need to adopt an *adaptive management strategy*.

The adaptive management process

Adaptive management is a cycle of management steps or events that facilitates planning, implementation of actions, monitoring of outcomes, and making adjustments to changing situations (Figure 4). The six steps or events in the process are

- establishing goals
- setting management priorities
- identifying appropriate methods
- developing and implementing an integrated weed management plan
- monitoring results
- modifying priorities and improving the management plan.

Establish goals

The first step in the adaptive management planning process is to establish and record management goals and fireweed management objectives. Management goals and objectives are those that the manager has set for the operation, such as producing high-quality calves for local sale, or maintaining pasture condition at maximum productivity. It is important that the weed management plan does not hinder or interfere with these production goals. When identifying management goals and objectives, it is important to have an adequate description of the property or unit to be managed. Likewise, an inventory of the distribution and level of fireweed infestations should be conducted on the property or unit. These activities will facilitate the planning process by providing an accurate description of the problem.

Fireweed management objectives should include preventive measures where the weed is not present, control measures where the weed is already established, and protocols for taking prompt action when fireweed first appears in an area. Once the management goals and fireweed management objectives are identified and recorded, the adaptive management process moves to the second step in the cycle.

Set management priorities

It is important in this step to identify areas where fireweed prevents the accomplishment of the goals and objectives for a sustainable operation identified in step one. Priorities are determined where an existing or potential fireweed infestation interferes with the sustainable productivity of the operation. Examples might include pastures used for calving, because lactating cows can pass PA on to their calves through their milk. Horse pastures may also be critical control areas, because horses are very susceptible to PA poisoning. Priorities should include prevention, control, and immediate response measures.

Identify appropriate methods

The next step in the adaptive management process is to select the appropriate methods to be used for the prevention, control, and immediate response measures. Managers need to carefully consider the different methods of control and select only those methods that are suited to the area, operation, and management goals and objectives. It may be necessary to reprioritize based on the likely impacts of the selected control methods on target and nontarget species, ecosystem function, and agricultural productivity (Table 2). Inappropriate methods may exacerbate the infestation or lead to other, more severe damage to the ecosystem, or they may not be economically feasible for the area to be treated.

No single management technique is perfect for all weed control situations. Often, multiple management actions are required for effective control of the weed. Integrated weed management plans should include the best combination of management techniques (biological, mechanical, chemical, and cultural controls) that will effectively and efficiently manage the target weed (Table 2).

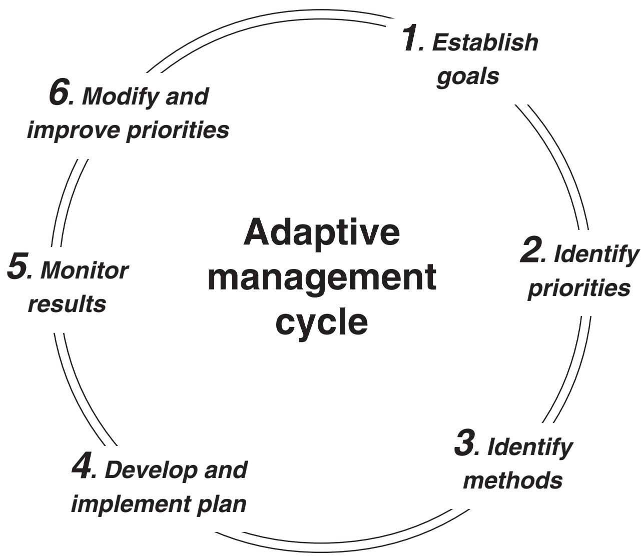
Develop and implement an integrated weed management plan

Once the appropriate weed management techniques have been considered and designated for each priority control area, it is time to develop and implement an integrated weed management plan. There are three primary principles that should guide development and implementation of an IWMP: (1) work to establish and maintain functioning desirable plant communities, (2) implement appropriate prevention methods, and (3) choose the appropriate control actions.

Proper grazing management of livestock is an essential component of an IWMP. Grazing management involves closely controlling the distribution, timing, and frequency of grazing and the kind and class of grazing animal. The grazing animal can be used as a tool to establish and maintain functioning desirable plant communities (Figures 5 and 6). When developing an IWMP, managers must also consider other land use practices that might contribute to disturbances, and make the appropriate changes.

Implementing appropriate preventive methods includes combining those preventive methods with normal land management and weed control activities. Preventing weeds from invading a site is the most effective and least costly method for controlling weeds. Managers need to be sure

Figure 4.



that the control actions implemented do not contribute to the spread of the weed.

The selected control actions should ideally be those that can be applied at the most effective time. Treatments should be applied at the point in the life cycle of the weed that it is the most vulnerable. Control methods must also be selected so as to be the least damaging to non-target organisms. Before implementation, managers should carefully consider the effects of the treatment combinations on both target and non-target species.

The control methods selected need to minimize the risk to human health and potential damage to the general environment. When selecting control methods, managers should consider those that have a greater potential to reduce the need for weed control measures over the long term and are easiest to implement. The easier it is to implement the control actions, the more likely it is that the plan will be completed. Finally, managers must be concerned with the cost-effectiveness of the control methods over the short and long terms. Managers should carefully consider the costs and benefits of the possible control actions in order to select the best combinations.

Monitor results

Monitoring is an essential component in the adaptive management process and is vital to the success of any integrated weed management plan. Monitoring is the collection and analysis of information for evaluation of progress toward established goals and objectives.[6] Periodic observation of the weed populations being managed is necessary to evaluate the effectiveness of the IWMP. An effective monitoring program will help managers save money by helping to determine what is and is not working. Weed control efforts that are not working need to be changed or discontinued; with monitoring, these changes can be made early in the program before it becomes costly.

When designing a monitoring program, there are three key factors to consider.

First, simple and straightforward monitoring programs are more likely to be completed—*and* be informative. How much effort a manager invests in monitoring depends on what could happen if the management actions are not working or are counter-productive. A higher risk of failure means more effort should go toward monitoring. For example, using livestock grazing to control weeds requires close and frequent attention to the available forage to avoid overgrazing. Likewise, eradication of a high-priority weed species may require more monitoring than suppression of a low-priority species.

Second, monitoring, like weed control, is an ongoing process. The information gathered in the early days of monitoring are valuable, but the value of that information is enhanced by comparison with every future piece of data. The likelihood of detecting useful trends increases with each year of monitoring.

Third, most monitoring programs cannot be used to determine cause and effect. Although monitoring data can reveal a change in weed species abundance, for example, the data will not indicate whether the weed control actions caused a change. It is possible that the change would have happened anyway, due to some change in weather conditions or other factors. Determination of cause and effect requires replicated, controlled experiments where relevant factors are controlled. Such experiments ordinarily are done by university and government researchers, but there may be situations where land managers may wish to conduct research trials. Land managers can contact the authors at their respective UH–CTAHR Cooperative Extension Service office locations to find out more about developing monitoring trials and experiments.

The first step in developing a monitoring program is to *set monitoring priorities*. Land managers need to establish a minimal level of monitoring for each high-priority weed species (in this case, fireweed) or weed infestation in each management unit where weed control actions are being applied. In addition, land managers should develop a system of recording and tracking herbicide applications and biocontrol organism releases, where appropriate.

Once monitoring priorities are set, land managers can select the appropriate *monitoring actions*. It is a challenge to find a balance between the time and money spent moni-

Figure 5. Fence-line contrast between pasture grazed continuously (left) and in rotation (right). Note the extensive fireweed distribution in the continuously grazed pasture. This photograph demonstrates the importance of providing adequate rest for pasture recovery following grazing.

Figure 6. Fence-line contrast between sheep-grazed pasture (right) and pasture not grazed by sheep (left). Note the density of fireweed on the left compared to the pasture on the right. This photograph demonstrates the value of multi-species grazing to control fireweed (photograph courtesy of Greg Friel).

toring and the value of the information gained from monitoring. The amount of time spent monitoring will determine the value of the information acquired and affect the manager's ability to determine if the management objectives are being met.

The methods used to monitor depend on the weed management objectives of the IWMP. Thus, the complexity of the monitoring program depends on what information is needed to determine if the weed management objectives are being met. Some highly effective monitoring actions or methods are listed below.

Written records. The most basic form of monitoring consists of taking careful notes of (1) the sizes of infestations in high-priority areas and the general abundance of weeds in those infestations, and (2) the general extent and abundance of weed species not found in high-priority areas.

Photographic records. Photographs can be extremely useful in documenting changes in weed populations over time. It is important that the photographs be taken from permanent locations (photo points). Photographs work best for monitoring weed species that can easily be distinguished from other plants. Examples include fireweed, lantana, apple of Sodom, and many other shrubby species found in Hawai'i range and pasture lands.

Electronic records. The size and treatment applications for weed infestations can be recorded in geographical information system (GIS) or spreadsheet formats. This allows for graphical tracking of results over time.

Estimating weed abundance. Land managers may need to estimate weed abundance in order to evaluate a particular weed management objective. Two standard measures of plant abundance are plant density (Figure 7) and plant cover (Figure 8).

For more information on techniques to quantify plant density and cover, contact one of the authors or consult the Web site <rangelands.manoa.hawaii.edu>, which contains a link to <cals.arizona.edu/agnic/az/monitoring.html>.

Monitoring actions should be tested before they are implemented in the field. It is easier to redesign a monitoring protocol after a failed test than to redesign the program in the middle of a monitoring period. Questions to consider when testing monitoring protocols include:

- Will the methods selected work in the field? It may be that it is not practical to count certain species to estimate density, or heavy vegetation may prevent uniform sampling over the management unit. Such problems are best dealt with early, before large amounts of time and resources are committed to a monitoring program.
- Is the cost and time commitment for the proposed monitoring program acceptable? It may be that collection of the data called for in the original monitoring program takes too long or is too expensive. Redesigning prior to implementation will ensure that the monitoring program is affordable.
- Will the observations allow detection of changes in the weed population? The bottom line is whether or not the monitoring program allows a land manager to evaluate the effectiveness of the weed control actions.

The most important step in any monitoring program is to begin. Without monitoring, land managers cannot determine if they are meeting their weed management objectives. Monitoring can save land managers money by ensuring that the control measures utilized are as effective as

Figure 7. Estimating plant density using a metal frame specially designed for the purpose. Plant density is the number of plants per unit area of ground surface.

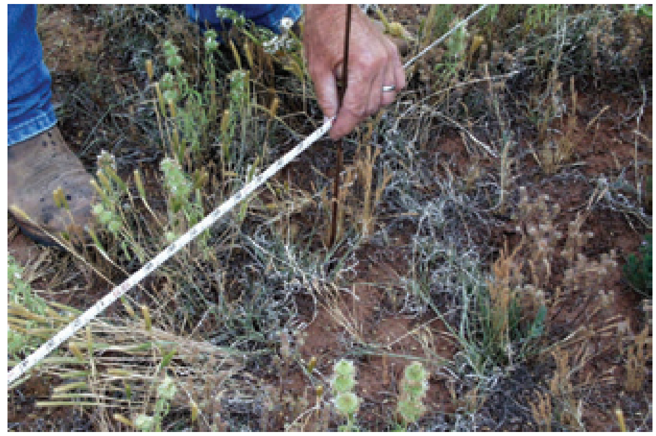


Figure 8. Estimating plant cover using a pointing rod and tape measure along a 100-ft transect line. Plant cover refers to the proportion of ground surface (expressed as a percent) hidden by plant foliage when viewed from overhead.

possible and allowing them to be flexible and adaptive to changing conditions.

Modify priorities and improve management plan

The final step in the adaptive management process is to modify priorities and improve the management plan according to developing needs and successes as indicated by the monitoring program. To be successful, weed control must be treated as a continual process that is constantly adapted to the situation as it develops. A well designed monitoring program will indicate when management priorities need to be changed or adjusted. For example, weed management efforts should be shifted to new high-priority areas as weed control activities in current high-priority areas become successful in controlling or suppressing the weed population. The timing of this shift in emphasis will vary depending on the overall goals and objectives of the IWMP, but it can only be correctly determined through monitoring. Likewise, weed control actions that are not successful should be terminated, and the management plan will need to be evaluated and adjusted accordingly.

Adaptive management is a cyclical process. Once priorities and plan goals and objectives are modified, the process begins again with the implementation of planed activities, monitoring, and evaluation and modification.

Summary

Successful control of fireweed in Hawai‘i requires the integration of various weed management actions. The integrated weed management planning principles outlined in this publication can help managers be successful in their efforts to control fireweed, and other weeds as well. When developing an IWMP, managers should utilize an adaptive management strategy, which will allow for flexibility in adjusting to changes in priorities and conditions as they develop.

For more information, please contact one of the authors. This publication was printed with support from the West Maui Soil and Water Conservation District. Photographs are by the authors unless otherwise noted.

Literature cited

1. Knight, A.P., and R.G. Walter. 2001. Chapter 4: Plants affecting the skin and liver. In: A guide to plant poisoning of animals in North America. Teton NewMedia, Jackson, Wyoming. p. 142–158.
2. Holtkamp, R.H., and J.R. Hosking. 1993. Insects and diseases of fireweed, *Senecio madagascariensis*, and the closely related *Senceio lautus* complex. Proc., 10th Australian and 14th AsianPacific Weed Science Soc. Conf., Brisbane, Australia. p. 104–106.
3. Motooka, P., G. Nagai, K. Onuma, M. DuPonte, A. Kawabata, G. Fukumoto, and J. Powley. 2004. Control of Madagascar ragwort (aka Madagascar fireweed, *Senecio madagascariensis*). University of Hawai‘i at Mānoa, College of Tropical Agriculture and Human Resources, publication WC-2 (revised).
4. Watson, R., T. Launders, and J. Macadam. 1984. Fireweed. Agfact P7.6.26. New South Wales Department of Agriculture, Scone, Australia.
5. Phister, J.A., K.E. Panter, D.R. Gardner, B.L. Stegelmeirer, M.H. Ralphs, R.J. Molyneux, and S.T. Lee. 2001. Alkaloids as antiquality factors in plants on western U.S. rangelands. J. Range Management 54:447–461.
6. Elzinga, C.L., D.W. Salzer, and J.W. Willoughby. 1998. Measuring and monitoring plant populations. Technical Reference 1730-1. Bureau of Land Management, National Business Center, Denver, Colorado.

Table 2. Weed management techniques and their uses and limitations.

Technique	Usefulness	Limitations
Pulling (using hands or implements to uproot plants)	Small infestations. Annual and biennial plants. Shallow-rooted plants. Situations where chemicals, motorized equipment or livestock cannot be used or are undesirable.	May not remove entire root system. Does not reduce soil seed bank. Is not cost-effective for large infestations.
Mowing and cutting	Large, relatively flat and dry areas that can be mowed safely. Preventing tall, erect plants from setting seed when other control techniques are not feasible. Weakening weed plants by depleting root and rhizome reserves. Combining with other control methods, such as herbicide treatment. Large-scale restorations.	Rarely kills weeds. Some sites are inaccessible. Mowing must be frequent for adequate control.
Cultural controls (cultivation, re-seeding, fertilizing, and irrigation)	Large restoration projects. Re-establishing native plant communities on disturbed or depleted areas.	Not normally suitable for natural communities. Lack of seeds from locally adapted plants. Cost of fertilizers, irrigation equipment, etc.
Livestock grazing	Weeds that are palatable and non-toxic (fireweed is palatable to sheep and is many times less toxic to them than to cattle). Low-level, widespread weed infestations where other control techniques are not cost-effective.	Availability of grazing animals (sheep, goats, or cattle) when needed. Need water, fencing, or herding to control movement. Need to manage timing, intensity, and duration of grazing.
Biological control agents	Reducing seed reproduction or weakening plants. Large, dense infestations where other control measures are not cost-effective. Situations where a reduced but effectively permanent presence of a noxious weed species is acceptable.	Failing to eradicate the target plant species. Feasible for only a handful of species because of costs associated with finding, screening, and testing potential agents. Rarely successful as the sole means of control
Herbicides	Eradicating some weed species in certain situations (fireweed is susceptible to 2,4-D, dicamba, MCPA, and triclopyr). Control of weeds when other methods are not feasible. Use in combination with other control methods.	Damaging or killing non-target species. Toxicity to humans to varying degrees. Property owners must posses a license to buy and apply restricted-use herbicides. Restricted-use herbicides are available only at licensed outlets. Some weeds can develop resistances to a particular herbicide over time.
Prescribed burning	Controlling weeds that are more susceptible to burning than non-target species.	Intensive planning is needed to ensure a safe and successful burn. Smoke management problems. Availability of crew members with “red card” certification. Experienced crews to manage prescribed burns. High risk of liability if fire escapes.