FOUNTAIN GRASS CONTROL IN HAWAII VOLCANOES NATIONAL PARK: MANAGEMENT CONSIDERATIONS AND STRATEGIES

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ABSTRACT

Fountain grass (*Pennisetum setaceum*), perceived as one of the most disruptive alien species in Hawaii, has threatened native ecosystems below 3,940 ft (1,200 m) elevation in Hawaii Volcanoes National Park for about 30 years. Because this species has spread rapidly to high densities on the leeward side of Hawai'i Island, invaded bare lava flows (which results in disruption of primary succession), has a broad elevational range (sea level to 6,500 ft (2,000 m) elevation), and has a tendency to raise fuel loadings, efforts to control this hardy bunchgrass have been part of the program of resource management at Hawaii Volcanoes since the early 1960s. In an attempt to increase efficacy of fountain grass control, data on distribution of the grass, treatment effectiveness, and work load requirements were collected beginning in 1979. On the basis of the information obtained from observation and control attempts, five management strategies were proposed in 1986; three of these have since been adopted to control this threat to Park ecosystems.

INTRODUCTION

Fountain grass (*Pennisetum setaceum*), native to Africa, was introduced to Hawai'i Island in the Kona district in the early part of the 20th century. It is now well established on the leeward side of the Island, with highest densities in North Kona, North Kohala, and the Pōhakuloa area. Scattered populations occur in windward areas, mostly in roadside habitats. Fountain grass is readily dispersed by vehicles, humans, wind, water, and possibly birds.

The species is perceived as one of the most disruptive alien plants in Hawai'i (Smith 1985). This large bunchgrass can form monospecific stands, is stimulated by fire, and enhances fuel loadings, thus endangering native woody plant communities it invades. Fountain grass differs from most other nonnative grasses in that it colonizes bare or sparsely vegetated lava flows, thereby disrupting primary succession. It grows in xeric and mesic habitats from sea level to above 8,990 ft (2,740 m) elevation (Jacobi, pers. comm.). Potential distribution in Hawaii Volcanoes National Park may include all areas outside closed-canopy rain forest. Therefore, a control program in the Park has also had to address fountain grass distribution in the vicinity of the Park.

Control programs have gradually expanded since Park managers first perceived fountain grass as an alien plant threat in the 1960s. At that time, a control program along Park roadsides was started. In 1979, efforts were expanded to a 900-a (400-ha) infestation adjacent to the Kamo'oali'i lava flows, an area in the southwestern part of the Park with the highest density of fountain grass. The primary treatment method consisted of uprooting plants by hand and destroying inflorescences to exhaust the soil seed bank. From 1979 to 1983 this control program was expanded to include treatment of roadside plants outside the Park, isolated populations near Kū'ē'ē Ruins and Pit Craters, and scattered populations found incidental to goat (*Capra hircus*) hunting by helicopter. Approximately $125,000 was spent from 1976 to 1983 on fountain grass control. Helicopter reconnaissance indicated that the range of fountain grass in the Park was much wider than previously thought.

The fountain grass control and monitoring program was again intensified in 1983 to achieve the following objectives:

1. Prevent the spread of fountain grass into other areas.
2. Determine the distribution of fountain grass in the Park and immediate vicinity.
3. Quantify the work load needed to control this weed.
4. Assess the effectiveness of treatments on population levels.
5. Monitor growth rate and onset of flowering.

Nearly $75,000 was spent during 1984 and 1985 to collect data incidental to control work. Managers were then able to evaluate the costs, impacts, and feasibility of different management strategies for fountain grass.

A management decision was made in 1985 to abandon control efforts within the interior portions of the major infestation in the Park lowlands, although control efforts were continued on known outlying populations, roadside populations, portions of a 0.6 to 1.25-mi (1-2-km) wide band at the periphery of the major infestation, and in Special Ecological Areas (Tunison and Stone, this volume). Funds were requested to expand the control program. Additionally, fountain grass was identified as a possibility for biological control research.

This paper outlines the decision-making process used in 1986 to formulate a new strategy for managing fountain grass, based on treatment effectiveness, distribution, and work load data collected in 1984-1985, and management priorities at that time.

MANAGEMENT CONSIDERATIONS

Distribution in the Park and Vicinity

Fountain grass distribution was mapped from helicopter, horseback, and on foot. The southwestern lowlands of Hawaii Volcanoes National Park were systematically searched on foot and horseback below 2,300 ft (700 m) elevation and west of the Mauna Ulu lava flows. The remaining dry habitats in the Park were scouted by helicopter at 100 to 330 ft (30-100 m) above the ground, from which larger plants could usually be detected, especially those on mostly bare lava flows. All developed roads surrounding the Park from Whittington Beach Park (outside the southwestern boundary of the Park) to Kapoho (outside the eastern boundary) were searched, as well as Powerline Road and some jeep trails outside the western boundary in the Ka'ū district near the Park. Local residents were queried about the presence of fountain grass on their lands. Some areas outside the Park, away from roads and adjacent to the infested areas, were surveyed by helicopter, while others that may support fountain grass were not. The numbers of plants in fountain grass populations (clusters of one to several thousand plants disjunct from other clusters of plants) were estimated or counted. All populations were mapped on 1:24,000 U.S. Geological Survey orthophotoquads.

In 1986, fountain grass away from roadsides occurred in two major infestations totalling approximately 19,800 a (8,000 ha) (Fig. 1). By far the largest group of populations occurred over 18,530 a (7,500 ha) in the southwestern corner of the Park and adjacent State land in Ka'ū, although densities were low throughout most of the Park. The smaller infestation of 1,235 a (500 ha) occurred north of Keauhou Landing. The area of highest density in the two infestations contained 5.9 plants/a (14.7 plants/ha) (after treatment), areas of moderate density 0.24 plants/a (0.6 plants/ha) (before treatment), and areas of low density, 0.12 plants/a (0.4 plants/ha) (before treatment). Two hundred ninety-eight small, isolated populations were located in areas of moderate and low density in the two infestations (Fig. 2). Fifty-six percent had one individual (when first discovered); 20% had two individuals; only 32 populations (11%) had six or more individuals.

Fourteen isolated populations with one or two plants each were located disjunct from the two large infestations (Fig. 1). Fountain grass was also scattered in 80 populations along roadsides inside and outside the Park in the districts of Ka'ū and Puna (Park population illustrated); 40 occurred in the Park, almost all along Chain of Craters Road and Highway 11 in Ka'ū, and 40 occurred outside the Park (not illustrated). A 1.24-a (0.5 ha) population occurred in Kalapana Village. Two populations in Ka'ū outside the Park and two populations along Chain of Craters Road inside the Park appeared to have spread 250 to 330 ft (75-100 m) from the roadside.

Although some fountain grass control work occurred from the mid-1960s to 1983, formal and systematic mapping was not conducted. Therefore, distribution data presented here serve as a baseline for the future, and densities shown in Figure 1 should be considered a conservative estimate. The range of fountain grass is therefore probably greater than indicated.

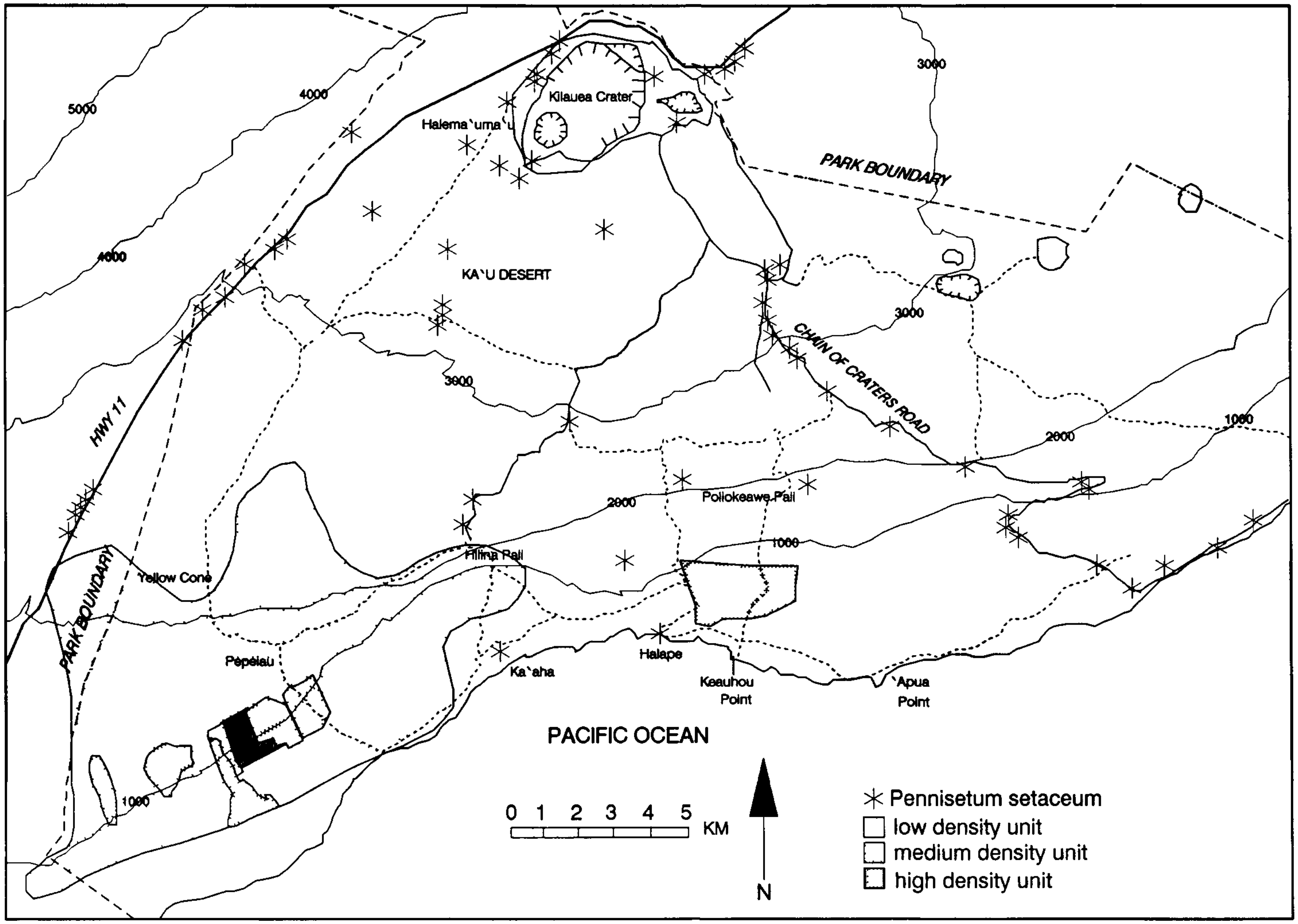


Figure 1. Distribution of fountain grass in Hawaii Volcanoes National Park and immediate vicinity, 1986.

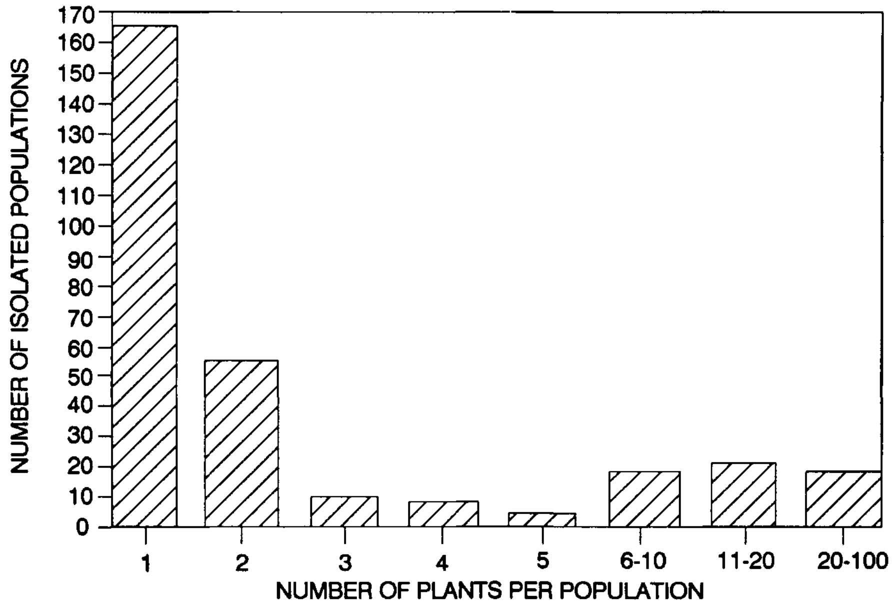


Figure 2. Number of fountain grass plants per population in 298 isolated populations in Hawaii Volcanoes National Park, 1986.

In the Park, large plants 5 to 20 years in age were found over the 1986 range of the plant, suggesting long establishment over a wide area. Search technique efficiency data (see below) indicate that many plants are overlooked during reconnaissance. Helicopter search was found to be only partially effective as a survey technique (see below).

The distribution pattern in the southwestern lowlands of the Park (Fig. 1) indicates widely scattered, small populations surrounding two central areas of higher population density (one on the Kamo'oali'i flows and one above Keauhou Landing). This distribution pattern suggests that fountain grass has been spreading from two centers of distribution, and that densities in the outlying portions of the range will increase over time.

Growth Rate and Phenology

Growth rates and onset of flowering of fountain grass were monitored to determine the time interval between treatments that precludes flowering, and to allow interpretation of search technique efficiency and distribution of plants encountered. The growth rate and phenology of 50 naturally occurring fountain grass plants were monitored for 49 months. The plants grew in a site with a light ash over pāhoehoe substrate at 820 ft (250 m) elevation adjacent to the Kamo'oali'i flows. They were located several meters from adjacent fountain grass plants in an area of moderate densities of Natal redtop (*Rhynchelytrum repens*) and pili grass (*Heteropogon contortus*). This area supported very large fountain grass plants at high density before control measures were taken. The mean length of monitored plants at the outset of the study was 20.7 in. (52.8 cm) (standard error = 3.60 (9.14)). Plants were monitored each year from 1985 to 1989, usually in the summer. The length of the longest leaves from ground level was measured. In addition, basal diameters were measured with a diameter tape at the soil line. The average basal diameter at the beginning of the study was 1.0 in. (2.7 cm) (standard error = 0.09 (0.23)). The date of onset of flowering and size of plant at flowering were also noted.

Thirteen of the 50 monitored plants were accidentally removed by field workers or died during the study. Their measurements were not used in the following calculations. The monitored plants grew in length an average of 4.6 in. (11.6 cm)/year (standard error = 1.40 (3.55)) (n = 37). Basal diameters grew an average of 3.0 in. (7.74 cm)/year (standard error = 0.31 (0.77)) (n = 37). Fifteen of the 37 plants flowered during the course of the study. The mean length when first monitored after flowering was 41.5 in. (105.5 cm) (standard error = 2.48 (6.30)). The mean basal diameter at the time of flowering was 2.5 in. (6.5 cm) (standard error = 0.12 (0.33)).

Qualitative observations by field workers indicated that fountain grass seems to grow much more rapidly and flower much earlier than shown by the growth rate and phenology data. This disparity is explainable by ineffectiveness of search techniques: field personnel miss plants. Growth rates may be greater in areas other than the study site, and growth rates may increase with age; however, growth rate data are not available from areas other than Kamo'oali'i. The growth rate data indicated that the age of the large plants found in the study area was greater than five years. These plants were typically 36 to 48 in. (91-122 cm) in length and 8 to 12 in. (20-30 cm) in basal diameter.

Search Technique Efficiency

The effectiveness of search techniques was tested in five areas by repeated scouting of the searched areas more intensively within a short time, or scouting again with the same or different search techniques. Helicopter searching was evaluated by surveying the target area from a helicopter and subsequently on foot. Search techniques on foot and horse were checked by searching surveyed areas again along more closely spaced transects. The spacing of transects between searchers on initial surveys from horse and on foot varied from 80 to 165 ft (25-50 m); the spacing on subsequent searches ranged from 35 to 80 ft (10-25 m). Growth rate data (see above) indicate that large fountain grass plants may be 5 to 20 years old; therefore, finding large plants in an area searched and controlled a few weeks previously was considered a reliable indicator of search technique efficiency.

In an area of low fountain grass density, where 24 populations were found by helicopter in late February 1984, 14 additional populations were found six weeks later. One week after that, a ground crew found five more populations in the same area. These populations consisted of 1-10 large plants. A four-person crew on foot found only one population in another area of low fountain grass density in which a two-person crew had found five populations two weeks previously. This four-person crew found six additional populations in an area of moderate density west of Pepeiau Shelter, where the two-person crew had found six populations three weeks before. Two searchers on horseback found no additional populations in another area of moderate fountain grass density at Kūkalau'ula that they had surveyed two weeks before. A five-person crew on horseback found 46 plants in a third area of moderate fountain grass density above Keauhou Landing. Two months later, a four-person crew on the ground found 56 additional large plants. Three months after that, a three-person crew on horseback located 43 large plants in this same area.

Efficiency data indicated that helicopter searching is the least effective search method. Only large plants can be seen from helicopter, as evidenced by the failure to find smaller plants in areas of high fountain grass density at Kamo'oali'i. A difference in lighting conditions is thought to account for finding a large number of populations on a follow-up helicopter survey. The data did not indicate that searching from horseback is more effective than searching on foot. Additional plants were found on follow-up surveys using either method.

Fountain grass plants are readily overlooked, even by the most effective searchers surveying along closely spaced transects from helicopter, on foot, or on horseback. Pāhoehoe tumuli, large aa boulders, and vegetation, particularly grasses, readily conceal small fountain grass plants. As a result, search transects need to be closely spaced and all areas within the infested areas should be searched systematically.

Treatment Effectiveness

Fountain grass was treated by uprooting plants and destroying inflorescences. Treatment effectiveness was determined by numbering and marking small populations on site, delineating larger ones with landmarks, and tracking the numbers and sizes of plants found at successive treatments.

Small plants (<2 ft or 0.6 m tall) found during follow-up treatments were presumed to be germinants of seed produced by plants of the isolated population monitored, if they occurred within 330 ft (100 m) of large plants found on first treatment. Larger plants or smaller plants found at greater distances were considered to be overlooked plants or new populations. Three hundred thirty feet (100 m) was used as a criterion because this distance may approximate the maximum for natural dispersal of fountain grass. This distance is substantiated by the pattern seen in three instances within the Park, in which distinctly disjunct large individuals were found during the survey with numerous small plants downwind for approximately 330 ft (100 m). Along stream drainages, apparent germinants occurred more than 330 ft downstream. Treatment effectiveness could not be monitored on a population by population basis in areas of continuous distribution. In these areas, the number of plants found and uprooted within the area of continuous distribution was noted.

The approximately 990-a (400-ha) infestation at Kamo'oali'i has been treated more or less regularly at three- to six-month intervals since 1979.

The number of plants found during each treatment has been recorded since 1982. A general decrease in number of plants has been found with successive treatments, with minor fluctuations associated with time of year (Fig. 3). Worker effort varied from treatment to treatment but was sufficient to find and uproot plants encountered in the block. In isolated populations, approximately 41% of the populations originally with one individual and 27% of the populations with two individuals did not have germinants when observed a second time after 2 to 20 months (Fig. 4). Isolated populations originally with three or more individuals almost always had germinants when observed during the second treatment (Fig. 4). The number of germinants dropped slightly with a third treatment in populations with one or two individuals (Fig. 5).

Short-term treatment effectiveness appears to be encouraging for small, isolated populations. However, one cannot reliably predict from favorable short-term responses that the seed bank has been exhausted in small populations. The lack of germinants may reflect recent conditions unfavorable for germination. More germinants may eventually be recruited from the seed bank. For example, 12 of the 56 small populations treated three times had no germinants the second time but germinants at the third treatment.

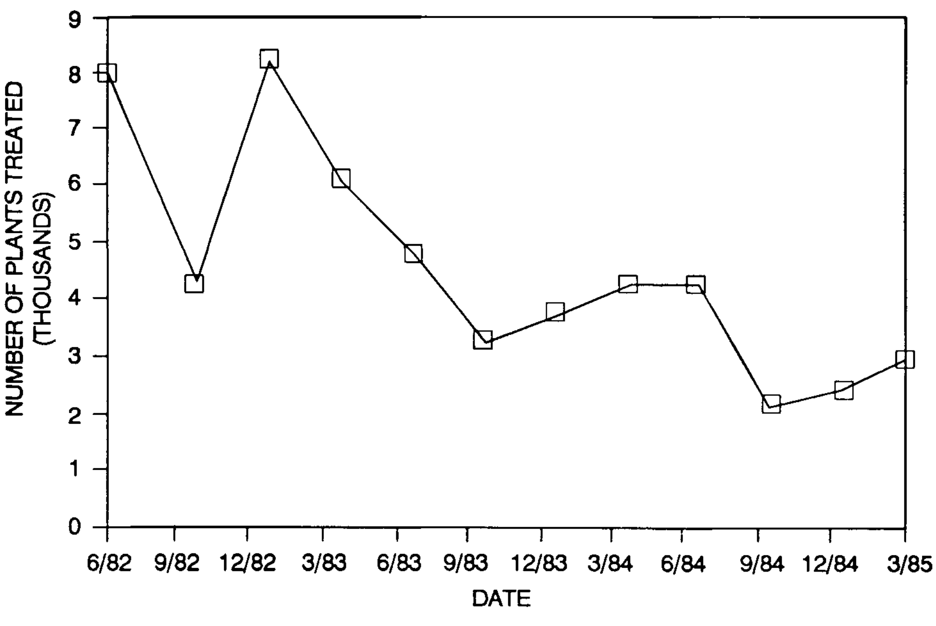


Figure 3. Number of plants through 1985 found at successive treatments in the 400-ha infestation adjacent to the Kamo'oali'i lava flows. The populations declined with control efforts at 3-4 mo intervals. Fewer plants were found in September of each year of the observation period, a trend perhaps reflecting germination during the dry summer months prior to the September treatment.

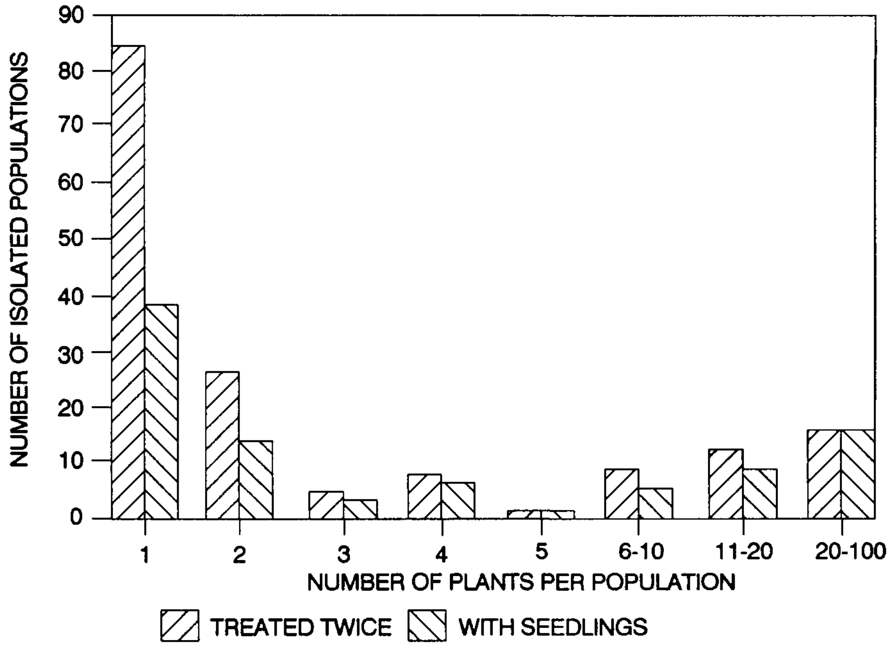


Figure 4. Number of plants found during a second treatment of isolated fountain grass populations, 1986. The left column of each pair indicates the number of populations of each size class treated two times. The right column indicates the number of populations of that size class found to have germinants during a second treatment.

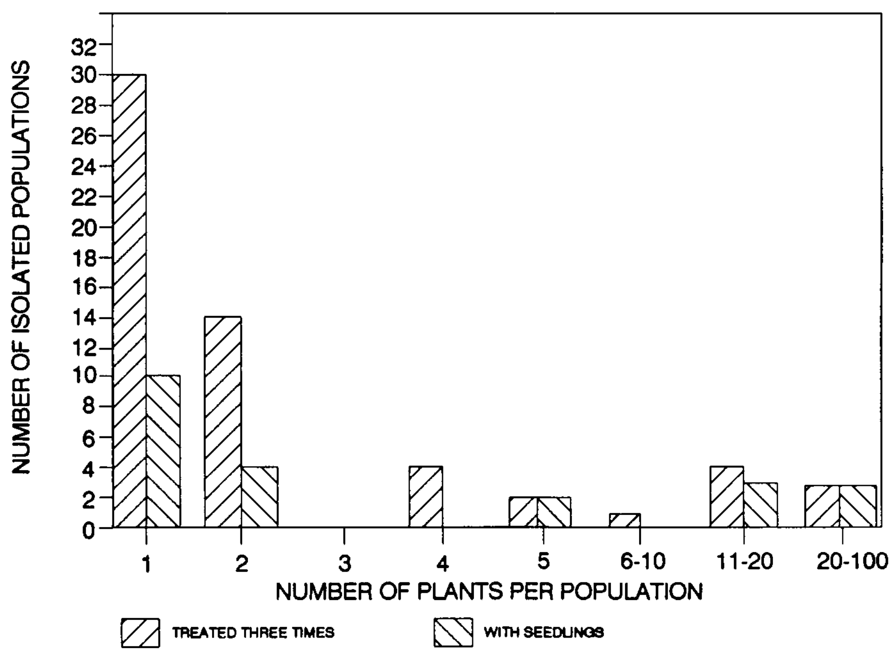


Figure 5. Number of plants found in 1986 during a third treatment of isolated fountain grass populations. The left column of each pair indicates the number of populations treated three times. The right column indicates the number of populations with germinants found at a third treatment.

The seed viability of fountain grass suggests that seed banks may persist for six or more years. Data are not available on viability of fountain grass seeds in soil. A short-term experin. .it at Hawaii Volcanoes National Park, terminated by an insect infestation at 18 months, showed a decline in viability from 80% to 44% of seeds stored in the laboratory under dry conditions. Treatment data at Kamo'oali'i suggested that fountain grass seed may be viable in the soil for several years. The great majority of the seedlings found at this site was probably recruited from the local seed bank because surrounding areas are of low fountain grass density. Approximately 1% of the plants at each treatment were flowering. The number of seeds contributed by these flowering plants was probably very low because of regular treatments, which precluded maturation and proliferation of inflorescences. The number of inflorescences per plant, typically immature spikes, rarely exceeded one or two.

Work load Requirements

The time required to systematically search and uproot fountain grass once in all infested areas was determined by recording the time spent systematically treating large sections of the infested area and extrapolating to the entire area. The spacing between parallel transects covered by adjacent searchers was 30 to 80 ft (10-25 m) for surveys on foot and 65 to 100 ft (20-30 m) for surveys on horseback. Distances between searchers varied with terrain and vegetation. Approximately 50% of the study area was surveyed with closely spaced transects.

Each searcher, working in teams of two to six individuals, was able to cover an average of 85 a (35 ha) per day. Surveys on horseback were slightly more efficient (95 a or 38 ha per day) than surveys on foot.

Work load requirements per year are based on three components: 1) The number of worker-days required to survey and treat fountain grass in infested areas one time; 2) the number of treatments needed per year; 3) the number of years that treatments are required.

The number of worker days required to survey and treat fountain grass was quantitatively determined. Determining the number of treatments needed per year and the number of years that treatments would be required would take several years of data collection from control programs. Growth rate data and onset of flowering do not address the question because workers tend to overlook plants, thus requiring more frequent searches to prevent flowering. The best estimate is that three or four searches would be needed per year, based on the frequency at Kamo'o'ali'i, which reduced population levels and percentage of plants with flowers to acceptable levels. However, less frequent searches may work in areas with lower densities of fountain grass.

Establishing the work load requirement is an empirical determination for which only a partial data base is currently available. The appropriate thoroughness of surveys and number of treatments needed per year can be adjusted on the basis of apparent treatment effectiveness as more data accumulate.

MANAGEMENT STRATEGIES: FEASIBILITY, IMPACTS, AND COSTS

Five strategies for managing fountain grass were considered by the Division of Resources Management at Hawaii Volcanoes National Park after three years of gathering the information and experience described above. The predicted biological effects and costs of each alternative are described.

Abandon conventional control efforts

The eventual range and ecological impact of fountain grass, if left unchecked, are uncertain. On the one hand, the soils, vegetation, and climatic regime in the Park differ from those in areas in which fountain grass has reached high densities over broad elevational and vegetational gradients. For example, high densities of other grasses in much of the submontane and montane seasonal habitat in the Park may preclude establishment of fountain grass at high densities. Furthermore, the Park has a policy of mandatory fire suppression, which may help limit the intensification of fountain grass. On the other hand, locally dense populations at Kamo'oali'i, Kalapana Village, and Punalu'u suggest that fountain grass in roadside sites in coastal areas can become very dense, reaching up to 50% cover. The spread of fountain grass populations in the Park and nearby areas to date may not provide an appropriate indication of spread potential; many populations may have established relatively recently and have not yet reached equilibrium levels.

A range of probable outcomes following abandonment of fountain grass control can be predicted. One scenario is that fountain grass will probably intensify along roadsides and spread from roadsides into surrounding areas, with continued expansion of infestation in Park lowlands. As a result, fountain grass would expand into most coastal lowland, submontane seasonal, montane seasonal, and subalpine environments at low densities. The plant will become a minor to important component of plant communities other than the coastal lowlands in Ka'ū District. Locally dense populations may occur on favorable substrates with adequate ash and low densities of other grasses. The occurrence of fire may be the most important factor in converting sparse populations to dense populations.

Another scenario is that fountain grass would expand into all plant communities except closed-canopy rain forest; areas of high fountain grass density would be common, and widespread fires will rapidly make fountain grass a dominant plant in many areas.

Rely Solely on Biological Control

Fountain grass is considered an undesirable, widely distributed weed by all interests in Hawai'i and is therefore an appropriate target for biological control efforts. Some limitations to successful biological control are:

1. Biological control agents may not be found. Markin *et al.* (this volume) indicated that success rates of biological control programs are

approximately 50%. Gardner and Davis (1982) indicated that no pathogens for fountain grass are reported in the literature.

2. Permits to import potential biocontrol agents may not be granted by State authorities because fountain grass is congeneric with a valued forage grass (kikuyu grass, *Pennisetum clandestinum*).

3. Biological control research and development may require 10 years or more (Markin *et al.*, this volume) and be only partially effective. Abandoning conventional control efforts in the meantime may permit considerable fountain grass range expansion and ecological disruption. Costs of development and application may average $1 million (Markin *et al.*, this volume).

4. Facilities and research personnel will be occupied with other target species unless priorities are rearranged, although some work on fountain grass may be started opportunistically.

M. Isherwood (pers. comm.) of the Hawaii Department of Agriculture has evaluated prospects for biological control of fountain grass and indicates that this approach is not feasible because of a poor scientific understanding of the species and the location of its natural range in politically unstable developing nations.

Control Fountain Grass Only in Special Ecological Areas

Under this strategy, fountain grass will not be controlled outside areas chosen to represent the most intact, diverse, representative, and manageable areas in Hawaii Volcanoes National Park. This is the same management strategy used with firetree (*Myrica faya*), kāhili ginger (*Hedychium gardnerianum*), strawberry guava (*Psidium cattleianum*), and other widespread species not controllable on a parkwide basis (Tunison and Stone, this volume). If effective, this management strategy would maintain fountain grass populations at very low levels in some of the richest, most intact plant communities representative of the range of vegetation types present in the Park. Fountain grass would spread and intensify in most areas outside of the Special Ecological Areas.

Predicting the feasibility and work load of controlling fountain grass in Special Ecological Areas is difficult for these reasons:

1. The eventual densities of fountain grass in areas surrounding Special Ecological Areas are uncertain; therefore, the magnitude of seed dispersal into these areas, and seedling establishment, cannot be predicted.

2. Colonization potential and rate of spread of fountain grass in the range of vegetation types found in Special Ecological Areas is unknown.

3. Designation of Special Ecological Areas has not been completed; consequently, the total area subject to fountain grass invasion is not known.

Fountain grass control in Special Ecological Areas surrounded by high densities of fountain grass may become highly labor intensive. However, large boundary-to-area ratios may result in lower seed dispersal rates into these areas; alternatively, small Special Ecological Areas may require small work loads commensurate with their size. The feasibility of controlling fountain grass in Special Ecological Areas is best determined by attempting it. Assuming that populations in Special Ecological Areas reach levels similar to those currently found in the infested area, controlling fountain grass by systematic searching at three- to four-month intervals in the entire 22,240 a (9,000 ha) of candidate or designated Special Ecological Areas (outside of closed rain forest) would require approximately as many worker days as controlling fountain grass in the existing infestation (Table 1): 9,000 ha at 35 ha per worker-day x 3.5 treatments/yr = 900 worker days. This figure may be reduced by treating fountain grass concurrently with firetree, because the most time-consuming part of fountain grass control is surveying on foot or horseback.

Confine Fountain Grass to the Lowlands

This management strategy consists of these elements:

1. Develop a fountain grass-free buffer zone around the upper elevations (3,940 ft or 1,200 m) of the Park through cooperation with neighboring ranchers.

2. Systematically and regularly control fountain grass in a buffer zone adjacent to the large infestation in the lowlands of the Park.

3. Treat all known outlying populations in the Park, especially those in Kalapana Village.

4. Treat fountain grass along all roadsides inside and immediately outside the Park.

5. Regularly scout within the Park above the buffer zone.

6. Control Kalapana area populations.

The feasibility of a quarantine strategy is based on the present distribution of fountain grass in the Park lowlands. Apparently, fountain grass is currently spreading by short-distance dispersal. The greatest disjunction of an isolated population within the main infestation in this Park lowlands infestation is approximately 0.6 mi (1 km).

Weaknesses of a quarantine strategy are:

1. As densities increase in the infested area, the probabilities of dispersal into uninfested areas increase, as does the work load of maintaining a buffer zone. Prevailing trade winds tend to blow seeds downhill and toward the coast. Occasional strong kona (southwesterly) winds may blow seeds uphill and across a buffer zone. The feasibility of a buffer zone adjacent to the major infestation can only be determined by attempting to maintain a buffer zone for a number of years.

2. Fountain grass may already occur outside the proposed buffer zone adjacent to the current infestation. These areas have not been thoroughly searched. More intensive surveys in 1986 indicate additional hitherto- unknown populations of fountain grass in the upper Ka'ū Desert.

3. Neighboring landowners have not agreed to control fountain grass on their lands. Control efforts are not economically feasible, and they believe that current grazing practices will limit the densities of fountain grass to acceptable levels. Even if they do control fountain grass, acceptable population levels may permit flowering and therefore a range expansion into the Park. Jacobi and Warshauer (this volume) have predicted the expansion of fountain grass into the upper-elevation plant communities on Mauna Loa between infested areas in Kona and Ka'ū and the Park.

Work load estimates (Table 1) can be calculated if it is assumed that populations in buffer zones will reach levels similar to those in the currently infested area; and that a 0.6-mi (1-km) wide buffer zone is regularly and systematically surveyed.

Table 1. Estimated work load for confining fountain grass to lowlands of Hawaii Volcanoes National Park.

Control Project	Worker-Days /Treatment	Treatments/Year	Worker-Days/Year
500 ha Buffer zone adjacent to infestation	43	3-4	130-170
Roadsides	10	3-4	60-80
Scouting outside known range	100	2	200
Outlying populations	50	3-4	150-200
Kalapana Village population	25	3-4	75-100
Total Field Time	228	----	615-750*

*150 worker-days of data management and administrative support should be added to this figure to indicate total work load involved.

Control Fountain Grass Parkwide

Treatment effectiveness data suggest that the sizes of large populations may be reduced. Control efforts on isolated populations are promising, but they have not been conducted over sufficient time to demonstrate that small, isolated populations can be eradicated. Seed viability and treatment data at Kamo'oali'i indicate that control programs must be carried out for at least five or six years, and possibly 10 years or longer. A major drawback to controlling fountain grass in the Park lowlands is that fountain grass also occurs adjacent to the Park and is continually introduced from these areas. These unmanaged infestations can be expected to intensify, expand, and spread into the Park.

The work load for controlling fountain grass parkwide, discussed in the section on Work load Requirements, is beyond current budgetary support (Table 2).

Table 2. Work load estimates for controlling fountain grass in the existing infestations in Hawaii Volcanoes National Park and vicinity.

Control Project	Worker-Days /Treatment	Treatments/Year	Worker-Days/Year
7,500 ha infestation (outside Kamo'oali'i)	215	3-4	645-860
Kamo'oali'i infestation	50	3-4	150-200
Roadsides	10	3-4	60-80
Scouting outside known range	100	2	200
Kalapana Village population	25	3-4	75-100
Total Field Time	400	----	1,130-1,440*

*150 worker-days of data management and administrative support should be added to this figure to indicate total work load involved.

MANAGEMENT OF FOUNTAIN GRASS

The fountain grass control program developed in 1986 included three of the five strategies considered. Control was undertaken in the following areas:

1. Along roadsides inside and immediately outside the Park, at four- to six-month intervals.

2. In Keamoku Special Ecological Area in the upper Ka'ū Desert, Kīpuka Puaulu Special Ecological Area and buffer zone, and 'Āinahou buffer zone, at 12- to 18-month intervals incidental to firetree control work. In all areas of Mauna Loa above Kīpuka Kī along pig activity transects at irregular intervals.

3. Along jeep roads in the upper Ka'ū Desert, every six months.

4. Populations disjunct from the main infestation, every three to four months. This includes populations above Keauhou Landing and the upper Ka'ū Desert.

5. All populations on the periphery of the main infested area in the Park and adjacent State lands. Much of the periphery of the infestation can be surveyed systematically on an annual basis. The intent is that, as control of these populations occurs, control efforts will be extended toward the center of the infestations.

6. Areas in the Park outside the main infestation. These were poorly surveyed in previous efforts and may indicate a distribution pattern with a bearing on the feasibility of a quarantine approach to controlling fountain grass.

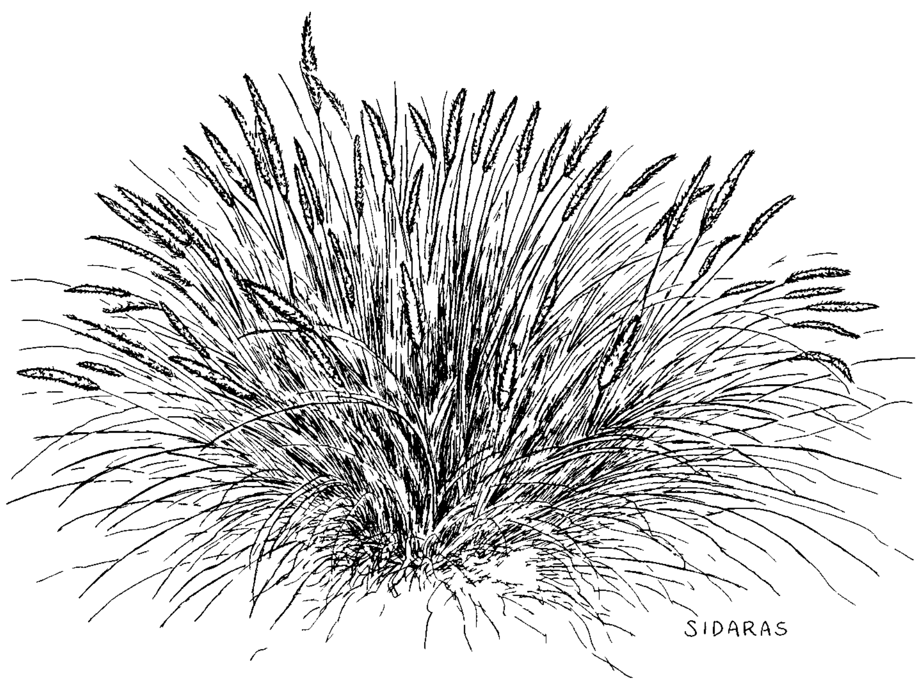
The above strategy was implemented for two years, and by 1988 it was apparent that control of outlying populations and in the buffer zone was a very effective approach. Several systematic searches were needed to locate all five small populations in the buffer zone, but once these were located and uprooted, there was little seedling recruitment. The work load thus dropped significantly, permitting managers to expand control efforts parkwide. By 1991, approximately 75% of the range of fountain grass was being regularly searched. The current (1991) management goal is control of fountain grass parkwide by continuing to expand efforts toward the center of the infestations.

RECOMMENDATIONS FOR FUTURE MANAGEMENT

Future management of fountain grass will depend on funding levels and spread of the species both inside and outside the Park. Fountain grass control should be conducted aggressively at the highest level possible without jeopardizing progress in feral animal control, localized alien plant control, and management of Special Ecological Areas. Parkwide fountain grass control should continue to be a high-priority funding request. The species should be controlled in Special Ecological Areas, along roadsides, and, to the extent that funding is available, in populations on the periphery of the main infestation. Control on the periphery should be made systematic, thereby creating a buffer zone to confine the lowland infestation to its current range. As funding becomes available, the buffer zone should be extended toward the central portions of the infested area. The infestation in Kalapana Village should be controlled.

Fountain grass has been targeted in the Resources Management Plan update for biological control, but it is a lower priority for biological control than banana poka (*Passiflora mollissima*), *Rubus* spp., and fire-tree. A request for additional funding to fully support conventional fountain grass control parkwide (Strategy 1) has been made, and an extensive monitoring program to detect changes in the density of fountain grass in infested areas has been established.

Monitoring the effectiveness and impacts of fountain grass control should continue. Densities within the untreated infested area should be followed, and colonization of new areas above the buffer zone should also be studied to determine the effectiveness of this approach. Upland areas on Mauna Loa outside the boundaries of Hawaii Volcanoes National Park should also be checked for encroachment of fountain grass. Changes in isolated populations within the treated zone should be evaluated to determine the feasibility of eradicating small, isolated populations. Progress in controlling the species parkwide will be described in a subsequent paper.



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