COOPERATIVE NATIONAL PARK RESOURCES STUDIES UNIT

DEPARTMENT OF BOTANY

UNIVERSITY OF HAWAII AT MANOA

HONOLULU, HAWAII 96822

(808) 948-8218

TECHNICAL REPORT #18
THE HILINA PALI FIRE: A CONTROLLED BURN EXERCISE

NATIONAL PARK SERVICE

CONTRACT NO. CX 8000 7 0008

Contribution Number CPSU/UH 005/5

Clifford W. Smith, Unit Director

THE HILINA PALI FIRE:
A CONTROLLED BURN EXERCISE

May 1977

Terry T. Parman and Kirk Wampler
Hawaii Volcanoes National Park
Hawaii 96718

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

The alteration of natural successional trends within Hawaii's native flora has been affected by many agents. The introduction of exotic plants and feral animals by the early Polynesians marked the first purposeful change in species composition and succession within the Islands. The subsequent addition by European man of numerous species of exotic plants has helped to alter substantially the process of natural succession in many plant communities throughout Hawai'i. The presence of these exotic species has, in many instances, increased the potential for further alteration of these communities by fire.

Fire has played an active, although sometimes overlooked, role in the succession of plant communities in Hawai'i (Vogl 1969). The area encompassed by Hawaii Volcanoes National Park has experienced frequent volcanic activity resulting in recurrent fires adjacent to new lava flows. Though Vogl (1969) indicates lightning to be a major cause of fires in Hawai'i, the evidence from Hawaii Volcanoes National Park indicates that most fires within the Park have been started by man in one way or another (Hawaii Volcanoes National Park 1977).

The intent of this study is to document the effects of fire in a mixed grass and shrub 'ōhi'a woodland, in an effort to provide information relevant to control and suppression of future fires within this ecosystem.

The Hilina Pali study area, an open 'ōhi'a-broomsedge-native shrub woodland, situated within the upper limits of the submontane seasonal ecosystem (Mueller-Dombois 1976) of Hawaii Volcanoes National Park (Figure 1), has been invaded by several species of exotic grasses and forbs within the last several decades. The most notable, and possibly the most aggressive, of these exotic introductions are the North American broomsedges, *Andropogon glomeratus* (Walt.) BSP. and *Andropogon virginicus* L. Although these species are relatively new introductions to the Hawaiian Islands (subsequent to 1906 [St. John 1973]), the introduction of *Andropogon* to areas within Hawaii Volcanoes National Park did not become markedly apparent until the mid- to late-1940's.* Photos taken prior to 1940 reveal that within the last 35 years, *Andropogon* has become an increasingly abundant component of mid-elevation plant communities within the Park. The distribution of *Andropogon* as of 1974 is shown in Figure 2. Though Mueller-Dombois and Fosberg used the 1954 USDA Soil Conservation Office aerial photographs to establish their vegetation zones within Hawaii Volcanoes National Park, the ground-proofing of the zones was done in 1972-74. Warshauer and Jacobi (1973)† have pointed out that Stone (1959) (who included the area in which this fire study took place) did not record *Andropogon* from the Kalapana Extension of the Park. The actual date of the *Andropogon* infestation in this area is not known.

The impact of this grass species upon the successional trends of native flora is not, as yet, fully understood. *Andropogon* appears to be most successful in areas where

---

*Personal communication, D. Reeser, Hawaii Volcanoes National Park.

†A biological survey of the lower Kamoamoa and Pūlama sections of Hawaii Volcanoes National Park. (Unpublished.)

previous vegetational perturbations exist, e.g., disturbance by feral animals, loss of plant cover due to fire, or habitat alteration due to man. Vegetation studies currently being conducted in other portions of the submontane seasonal and montane rain forest ecosystems of Hawaii Volcanoes National Park indicate that soil scarification by feral pigs contributes substantially to the spread of *Andropogon* within these ecosystems (Parman, unpub.).

Habitat alteration by man also enhances the spread of this grass. The realignment of the Belt Highway in the Puna District in 1974, just outside the boundary of Hawaii Volcanoes National Park, provides a good example of this. Scattered clumps of *Andropogon* have invaded the shoulders of the road as a result of clearing and now extend 3 to 5 m into the undisturbed 'ōhi'a forest which borders the roadway. Although habitat alteration by man and rooting by feral animals play a significant role in the spread of *Andropogon*, fire appears to be the perturbation most conducive to its increase in cover (Kartawinata and Mueller-Dombois 1972).

Preliminary results of this study suggest that *Andropogon* responds quite favorably to disturbance by fire within mixed grass-shrub communities at mid-elevations of Hawaii Volcanoes National Park.

MATERIALS AND METHODS

The study area

The study area is located on the southwest flank of Kilauea Volcano within Hawaii Volcanoes National Park at an elevation of 1009 m (3310 ft), and is immediately adjacent to the Hilina Pali Road, approximately 1.75 miles southwest of the Chain of Craters Road junction with the Hilina Pali Road (Figure 1).

Vegetation within the study area is generally a very open canopy 'ōhi'a forest with an understory of native shrubs, interspersed with mixed grasses and sedges. Four endemic shrub species, *Vaccinium reticulatum* Sm., *Dodonaea sandwicensis* Sherff, *Styphelia tameiameiae* (Cham.) F. Muell., and *Railliardia ciliolata** DC. (na'ena'e) comprise a large portion of the understory vegetation, although the introduced grass *Andropogon glomeratus* is the dominant understory component within the community. To avoid any unnecessary confusion, all taxonomy in this report follows St. John (1973). Although some disagreement does exist concerning the nomenclature of Hawaiian plants, St. John's list is the most recent and complete summary of flowering plants in Hawai'i to date.

The climate throughout this area is tropical submontane, with a six-month dry season extending from April through September. Mean annual rainfall in this region is 1500 mm. Substrate within the study area is characterized by shallow ash soil 3 to 25 cm in depth. This thin layer of ash soil overlies a deeper substratum of massive pāhoehoe (Table 3).

---

*Also known as *Dubautia ciliolata* (DC.) Keck.

Plot preparations

Prior to the actual burning of the 0.405 hectare (1 acre) study site, a 1-m-wide fire break was cleared on three sides of the site to prevent accidental spread of the fire. The Kalanaokuaiki Pali, a 9-m-(30-ft-)high fault scarp, borders the study site on the south side, which eliminated the need of establishing a fire break on that side.

Measurements

Rate of spread. A line transect 11 m (36 ft) in length was established to ascertain the rate of spread of the fire. Twelve metal stakes were placed at 0.9-m (3-ft) intervals along the transect and the elapsed time of the fire passing from the beginning to the end of the transect was recorded.

Fire Temperature. Two bimetalic chromium-aluminum thermocouples, situated at ground level and also at the crown level of understory vegetation (approximately 1 m [3 ft] above ground), were extended from the fire break to the center of the burn area to assess the temperature of the fire. Temperature measurements of fire intensity were determined by the use of a "Homark Electronic Thermometer" (Type #1609 Cr/Al) connected to the two bimetalic thermocouples.

Cover. Percent cover by species of understory vegetation was determined before the fire utilizing two 60-m (197-ft) line transects established within the study plot (Table 1). Sampling was conducted using the point-intercept method. Point sampling along the two transects was executed using finely sharpened bronze rods mounted in a 1-m- (3.28-ft-)long wooden frame. Five points per meter, at 20-cm (0.66-ft) intervals, were sampled along each of the 60-m (197-ft) transects, so that 600 points total were recorded inside the study area. Point sampling along the same two 60-m (197-ft) transects was carried out at six-month intervals after the fire to assess the regeneration and succession patterns of the understory vegetation.

A control plot consisting of a single 60-m line transect was also established prior to the fire, immediately adjacent to the study plot, to monitor seasonal changes in species composition and cover values. An analysis of community structure, species composition, and cover values before the fire revealed no significant differences between the study and control plots (Tables 1 and 2). Sampling in the control plot was conducted concurrently with sampling in the study plot using the point-intercept method.

Percent cover values for the single tree species present *Metrosideros collina* subsp. *polymorpha* (Gaud.) Rock, were recorded only for those trees shorter than 1 m (3 ft) (Tables 1 and 2). Each tree taller than 1 m (3 ft) which was affected by the fire was monitored for evidence of regenerative success.

RESULTS

Species composition and cover values before the fire

Table 1 and Figures 3, 4, and 5 show cover values recorded for understory vegetation within the study site before the fire. Table 2 and Figure 6 show cover values recorded for understory vegetation within the control plot before the fire. All species present in the study and control plots were recorded during sampling conducted prior to the fire (Appendix).

Seven of the 16 plant species occurring within the study plot are endemic to Hawai'i; four of these seven are perennial shrubs. Before the burn, these four shrubs together accounted for 21.6% of all ground cover in the study plot (Figure 3). *Styphelia*, the most abundant shrub, occupied 12% of the plot, followed by *Dodonaea* (5%), *Railliardia* (4%), and *Vaccinium* (0.6%). The endemic sedge *Carex wahuensis* C.A. Mey. covered 4.6% of the ground inside the study plot. Young shoots of 'ōhi'a (those less than 1 m [3 ft] high) occupied 1.6% of the study area previous to the fire. A total of 27.8% of the understory plant cover before the fire was represented by endemic species.

The remaining eight plant species identified in the study area were all exotic. Sampling before the fire revealed that *Andropogon* exhibited the largest cover value for any single species in the study plot (20.6%). The small introduced sedge *Bulbostylis capillaris* (L.) C.B. Clarke accounted for 2.0% of the ground cover before the fire. Four other small herbaceous exotics, predominantly *Erigeron canadensis* L. and the grass *Melinis minutiflora* Beauv. comprised the remaining 5% of the plant cover within the study plot. Endemic plants, predominantly shrubs, accounted for 27.8% of the plant cover in the study area; exotic plants occupied 28.2% of the area (Table 1). It should be noted that the introduced grass *Andropogon* accounted for 72% of all exotic plant cover before the fire. Prior to the fire, barren ground occupied 14.6% of the study area while plant litter accounted for 28.6% of the ground area within the plot.

A description of the fire. The early afternoon of 5 May 1975 was chosen by Park supervisory personnel to initiate the burning of the study area. Basic meteorological data were collected immediately prior to the burn (Table 4). Ignition of the study site during the afternoon was chosen in an effort to maximize the intensity of the fire. Maximum temperatures and minimum humidity readings, those most conducive to rapid spread of fire, are usually observed to occur in this area during the mid to late afternoon hours of the day (National Fire Danger Rating System). Two parameters were measured during the fire (Table 4): rate of spread and maximum temperatures generated by the fire. Fire temperatures were measured at two height intervals: ground level and at 1 m (3 ft) above the ground (the approximate maximum canopy height of the understory). Maximum temperatures generated at ground level were considerably lower than those recorded 1 m (3 ft) above the ground (Table 4). The 240°C difference between ground and understory crown levels is not unusual, as the maximum temperatures generated by shrub and grassland fires are usually produced well above the ground, at or near the apex of the flames (Vogl 1974).

Despite the relatively high temperatures recorded at ground and understory crown heights, complete consumption of available fuels was not observed. Basal portions of moisture-laden woody shrubs, small trees (<1 m), and tufts of *Andropogon*, although extensively charred, were not completely consumed by the fire. Substantial portions of basal 'ōhi'a trunk bark (below 2 m or 6.5 ft) were severely damaged by the fire, yet the crown canopies of these trees, in most instances, were not ignited by the fire.

Regeneration after six months

Recovery of plant species within the burned area progressed slowly during the first six months following the fire. Monthly rainfall at the study site averaged 1.65 cm (0.65 in) from 1 May through 1 November 1975, resulting in minimal regeneration of previously existing species, as well as inhibiting the incidence of newly invading species.

The November sampling revealed 81% of the study area to be void of vegetation six months after the fire. The most abundant component of the community was *Andropogon*, which occupied 3.8% of the study site. Almost equally aggressive in reinvading the area was the exotic sedge *Bulbostylis*

(Figure 4, Table 1). Two exotic herbaceous plants, *Hypochaeris radicata* and *Erigeron canadensis*, reinvaded the area with moderate success. The exotic grass *Melinis minutiflora* also exhibited a favorable regenerative response to fire, occupying almost the same cover area six months after the fire as it had before the fire. No signs of regeneration among the four endemic shrubs were observed during the first six-month sampling period.

Regeneration after one year

A major increase in the cover value for *Andropogon* was observed during the second six-month period following the fire (Figure 4, Table 1). *Andropogon* not only increased its cover percentage five-fold in this short time span, but, by May 1976, actually covered a greater area than it occupied prior to the fire. Two other exotics, *Melinis* and *Bulbostylis*, exhibited evidence of their ability to respond favorably to fire by doubling the cover values recorded for them six months earlier.

The invasion of the study area in November 1975 by *Hypochaeris* and *Erigeron* appears to be temporary or at best seasonal, as the cover percentages recorded in May 1976 for these species totaled less than 50% of the values noted six months earlier.

Barren ground decreased some 19%, i.e., from 81% in November 1975 to 62% in May 1976. It is interesting to note that this reduction in barren ground closely parallels the increase in cover attained by *Andropogon* during this sampling interval.

Endemic vegetation continued to be poorly represented after one year of recovery, with only one native species, *Railliardia ciliolata*, occupying the study area. By May 1976, one full year after the fire, none of the 216 'ōhi'a trees affected by the fire showed any indication of regeneration. The crown canopy portions of virtually every tree inside the study plot were observed to have experienced severe desiccation with noticeable loss of crown foliage, despite the fact that the canopy had not been ignited by the fire. Even those leaves that remained attached to the tree appeared to be dead or dying, suggesting that the fire had been severe enough to damage the cambium, consequently inhibiting water transport to the upper sections of the tree.

Regeneration after 18 months

The November 1976 sampling revealed only moderate increases in cover values for all species present in May 1976. The three dominant exotic species, *Andropogon*, *Melinis*, and *Bulbostylis* (Figure 4, Table 1), together occupied 33.2% of the study area and comprised 93% of all live plant cover present eighteen months after the fire. Of low quantitative importance were the two exotic herbs, *Hypochaeris* and *Erigeron*, which experienced a continued decrease in cover. In November 1976 the plot was again dominated by large stands of *Andropogon*, although three previously occurring endemic species, *Dodonaea*, *Carex*, and *Vaccinium*, had reestablished themselves within the study plot. The most abundant of these three native species was the sedge *Carex wahuensis*, which accounted for only a scant 0.5% of the total plant cover.

The most successful native shrub to reinvade the area thus far is *Vaccinium reticulatum*. Although the November 1976 sampling showed that it attained a cover value of only 0.33% (Table 1), its density appears to be as high as, if not higher than, that of *Carex* (pers. obs.). If competition from *Andropogon* does not become increasingly serious, *Vaccinium* shows the greatest potential for reestablishment of any of the previously occurring shrubs. The only other native shrub encountered during the November 1976 sampling period was *Dodonaea*. A sizeable number of these small (<10 cm [3.9 in]), newly emergent seedlings were observed to be inhabiting the study area at that time. Surprisingly, *Railliardia*, the first endemic shrub to reinvade the area (Table 1, May 1976), was not encountered in the point sampling, although its presence in November 1976 was again noted.

Perhaps the most encouraging result of the November 1976 sampling was the high rate of regeneration of 'ōhi'a. Basal root sprouting of burned 'ōhi'a trees was first observed in mid-June 1976, and by November 1976, 112 out of 216 'ōhi'a trees (51.8%) within the study plot exhibited some indication of regeneration.

Sampling of the control plot revealed no significant changes in species cover values, with the exception of a continued decrease in exotic herbaceous plants, notably *Hypochaeris* and *Erigeron*, during the 18 months following the fire (Table 2 and Figure 6). The decrease in exotic herbaceous species noted in the control plot was also observed to occur in the study plot during the 18-month recovery period (Table 1).

DISCUSSION AND CONCLUSIONS

Three basic parameters were selected for use in assessing community regeneration and succession in this exotic-mixed-grass/native-shrub/'ōhi'a woodland: community structure, species composition, and species cover percentages.

Data collected in the study plot indicates that fire within this community appreciably alters two of these parameters: species cover percentages and community structure (Table 1 and Figure 5).

Perhaps the most dramatic change observed in the study plot following the fire was the alteration of community structure. The almost total lack of regeneration among the native shrubs, combined with a significant increase in mean crown height of *Andropogon* (0.9 m before the fire compared to 1.4 m in November 1976) creates a striking contrast in understory structure between the study plot and the control plot. The alteration of understory structure within the study plot is paralleled by the changes recorded for species cover values. By November 1976 exotic vegetation had increased in total cover by almost 6% (from 28.2% before the fire to 34.7% in November 1976). Endemic vegetation decreased in total cover by 26%, declining from 27.8% before the fire to only 1.03% in November 1976 (Table 1). Species composition within the study plot was surprisingly unaffected by the fire with no additions or deletions to the species list being noted during the 18-month recovery period.

Changes in species cover values within the control plot were insignificant, reflecting only the seasonal variation in environmental conditions. Species composition and community structure in the control plot remained unchanged throughout the 1.5-year sampling period.

Two questions can be considered as data are collected during this study:

1. Does fire play a major role in the alteration of species composition and amount, within exotic-mixed-grass/native-shrub/'ōhi'a woodlands?
2. What is the extent of that change as a result of disturbance by fire?

While these two questions cannot be fully answered until a pattern of community stability is attained within the study area, several emerging trends merit short discussion at this time.

Exotic species appear to be more favorably adapted to fire than the endemic species that occupy this habitat.

Following disturbance by this fire, *Andropogon* was extremely successful in reestablishing itself as an increasingly dominant component of the ecosystem. Preliminary data suggest that *Andropogon* is an aggressive invader of fire-disturbed, mid-elevation, mixed grass-shrub communities. This trend is supported by the increased quantitative importance exhibited by *Andropogon* relative to the previously occurring native shrub species.

The only tree species present, *Metrosideros collina* ('ōhi'a), appears to be the most favorably fire-adapted native species inhabiting the study area. Although the first signs of regeneration of 'ōhi'a were not observed until June 1976 (13 months after the fire), the regeneration of 'ōhi'a since that time has been dramatic. Barring adverse competition from the exotic members of the community, 'ōhi'a should be able to continue a stable, although slow, pattern of regenerative success.

Styphelia, which was the most abundant shrub before the fire, was the one shrub which showed no regeneration during the study period. A similar result has been obtained in a companion study at a higher elevation along the Mauna Loa strip road in Hawaii Volcanoes National Park. Lamoureux (personal communication) and Warshauer (personal communication) have also verified this observation from their studies of burned-over areas. The sampling technique for measuring cover is not at fault because the whole study area has been walked over extensively looking for *Styphelia* seedlings. None have been observed.

Though the significance of the high recovery rate of the exotic species should not be minimized, a word of caution about overemphasizing the remarkable growth rate of the exotic species in comparison with the native species is necessary. It is not surprising that the exotic herbs have grown as rapidly as they have. Herbs and forbs are characterized by their rapid growth and frequently constitute a major segment of the early succession of recently disturbed areas. On the other hand it is not unexpected that the endemic species in this area, which are represented by shrub and tree growth forms, are much slower at recovering. We will have to wait a number of years to see whether or not the native shrubs and trees do recover or whether the increased cover of the exotic species has an impact upon the reestablishment of the endemic species.

Figures 1 + 2 missing

(pages 17 & 18)

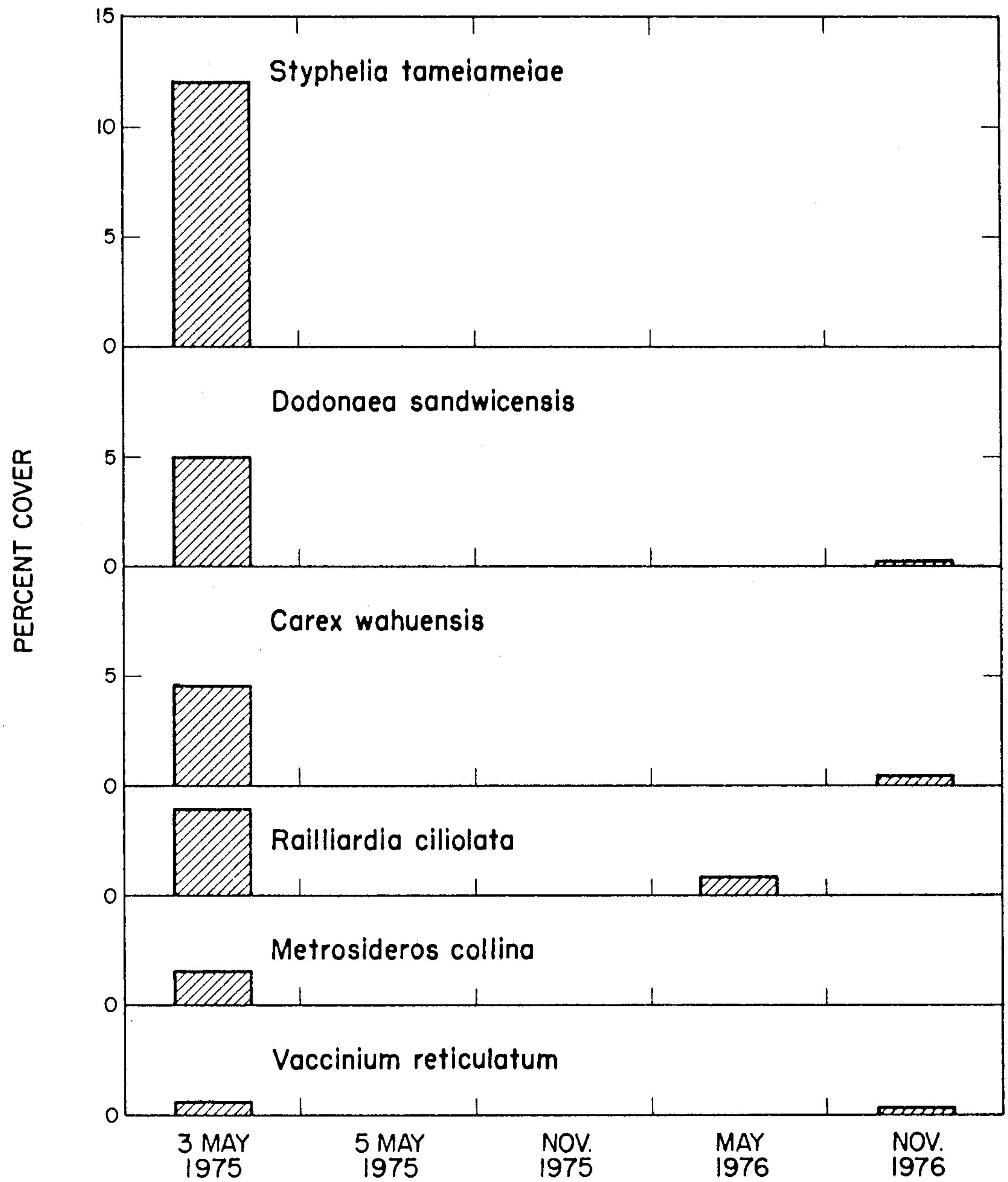

FIGURE 3. Cover values for endemic species in study plot before and after Hilina Pali fire of 5 May 1976.

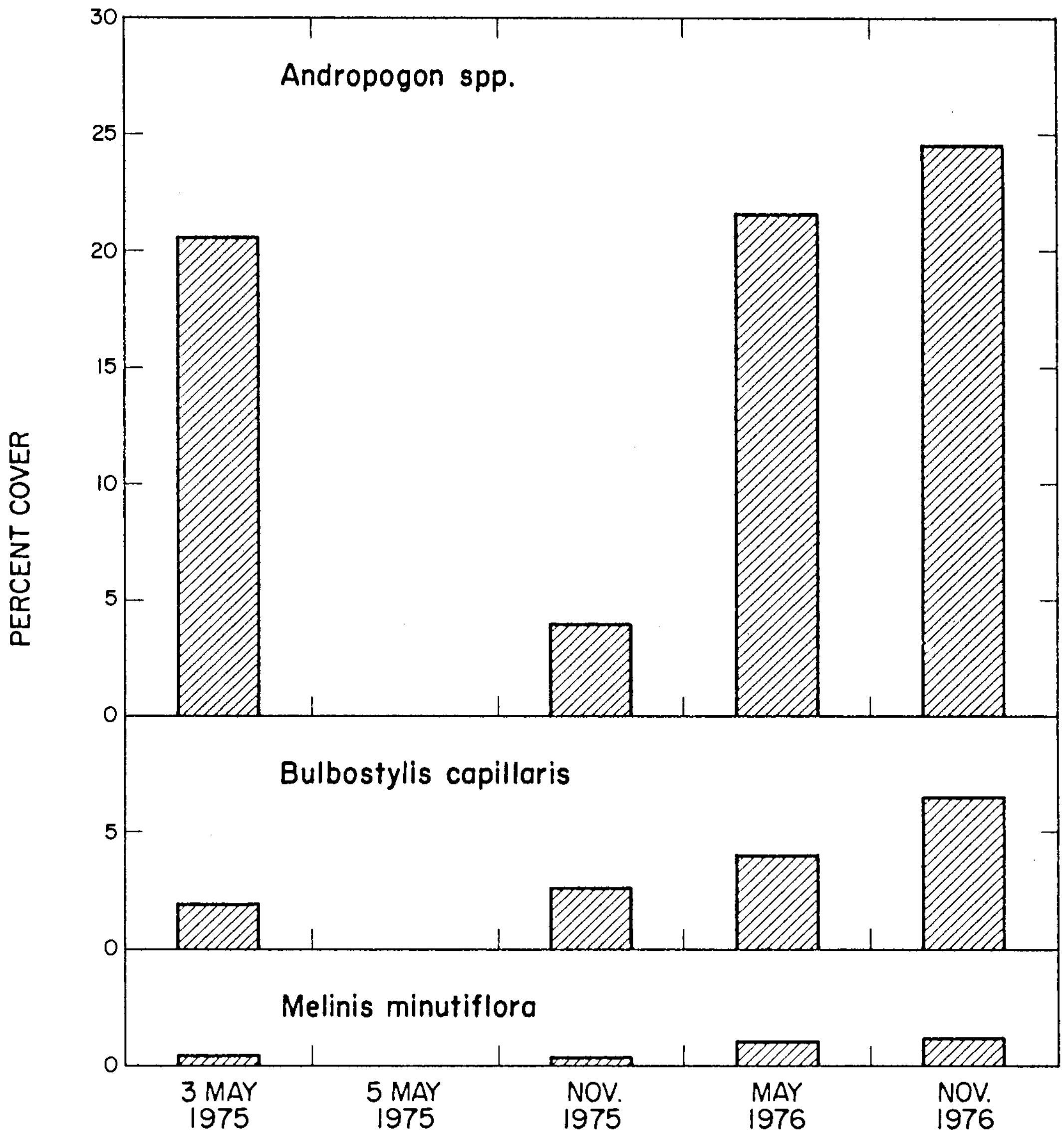

FIGURE 4. Cover values for exotic species in study plot before and after Hilina Pali fire of 5 May 1976.

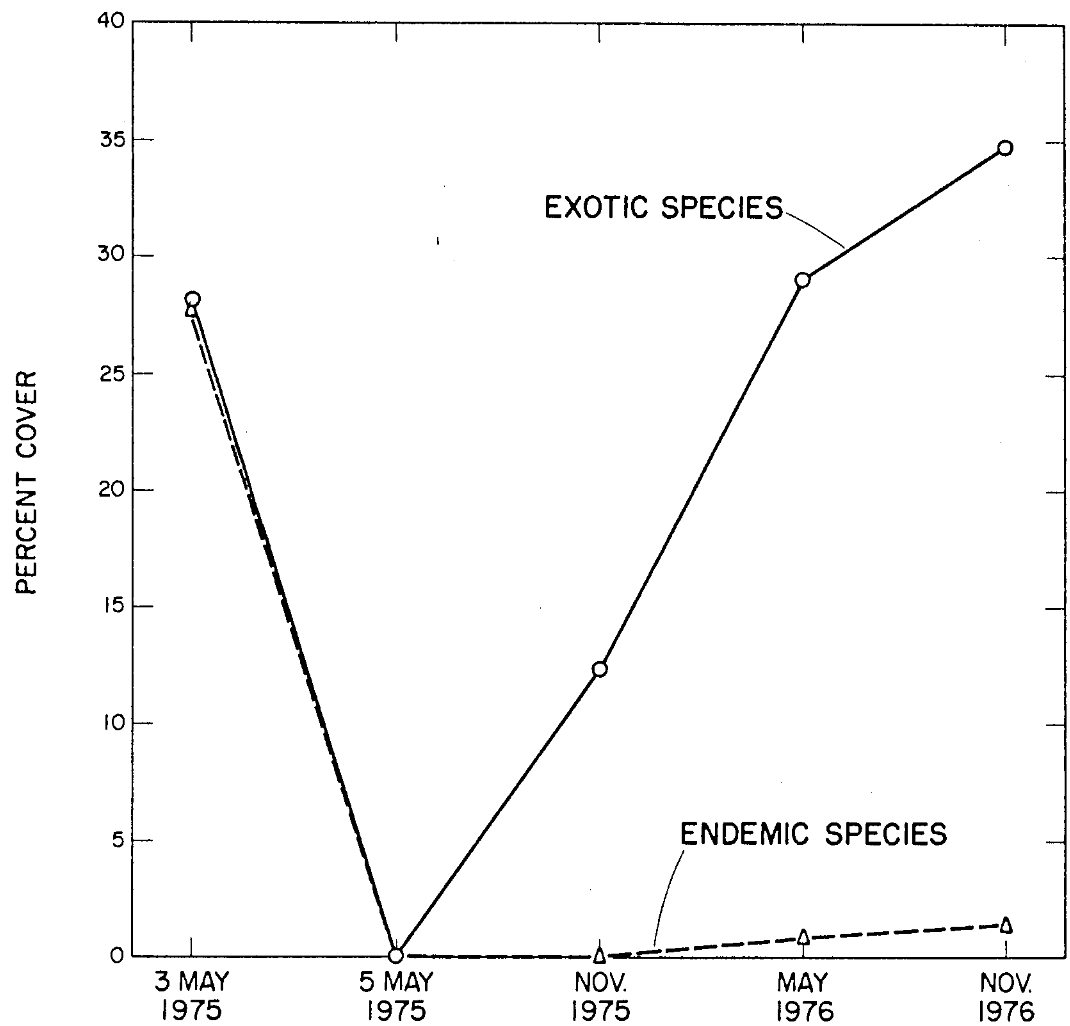

FIGURE 5. Total cover values for endemic and exotic species in study plot before and after Hilina Pali fire of 5 May 1976.

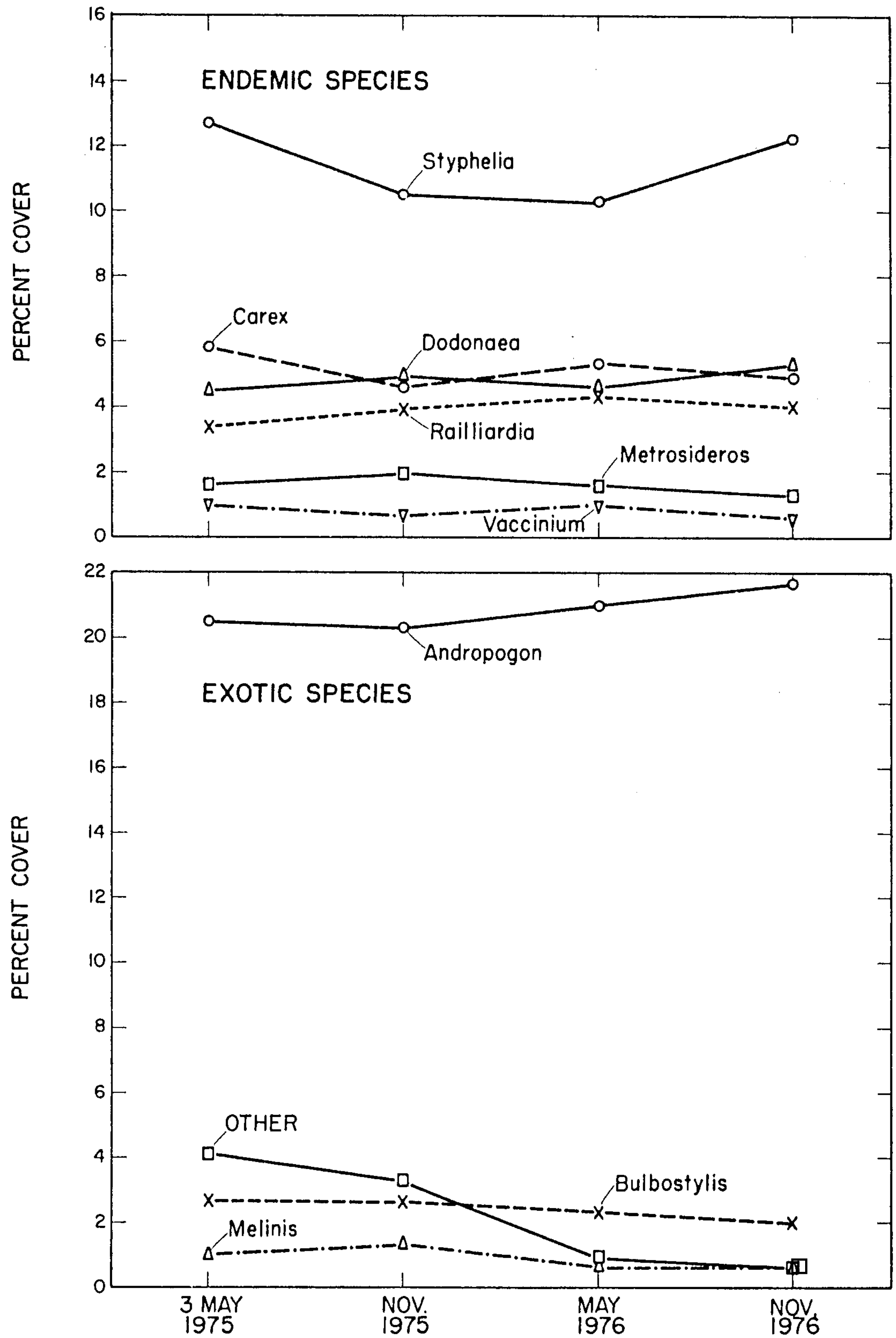

FIGURE 6. Cover values for control plot before and after Hilina Pali fire of 5 May 1976.

TABLE 1. Percent cover by species, before and after the Hilina Pali fire of 5 May 1976, in study plot.

Species	Before	After		
	3 May 1975	Nov. 1975 (6 mo)	May 1976 (12 mo)	Nov. 1976 (18 mo)
ENDEMIC SPECIES				
Styphelia tameiameiae	12.0	0	0	0
Dodonaea sandwicensis	5.0	0	0	0.2
Carex wahuensis	4.6	0	0	0.5
Railliardia ciliolata	4.0	0	0.8	0
Metrosideros collina (<1 m)	1.6	0	0	0
Vaccinium reticulatum	0.6	0	0	0.33
TOTAL ENDEMIC SPP.	27.8	0	0.8	1.03
EXOTIC SPECIES				
Andropogon spp..	20.6	4.0	21.6	24.6
Bulbostylis capillaris	2.0	2.7	4.1	6.5
Melinis minutiflora	0.5	0.4	1.12	2.17
Other	5.0	5.2	2.3	1.5
TOTAL EXOTIC SPP.	28.2	12.3	29.1	34.7
TOTAL PLANT COVER	56.0	12.3	29.9	35.73

TABLE 2. Percent cover by species, before and after the Hilina Pali fire of 5 May 1975, in control plot.

Species	Before	After		
	3 May 1975	Nov. 1975 (6 mo)	May 1976 (12 mo)	Nov. 1976 (18 mo)
ENDEMIC SPECIES				
Styphelia tameiameiae	12.7	10.5	10.3	12.2
Dodonaea sandwicensis	4.5	4.9	4.6	5.3
Carex wahuensis	5.8	4.6	5.3	4.9
Railliardia ciliolata	3.4	3.9	4.3	4.0
Metrosideros collina (<1 m)	1.6	1.9	1.6	1.3
Vaccinium reticulatum	1.0	0.6	1.0	0.6
TOTAL ENDEMIC SPP.	29.0	26.4	27.1	28.3
EXOTIC SPECIES				
Andropogon spp.	20.5	20.3	21.0	21.7
Bulbostylis capillaris	2.7	2.6	2.3	2.0
Melinis minutiflora	1.0	1.3	0.6	0.6
Other	4.1	3.3	0.9	0.6
TOTAL EXOTIC SPP.	28.3	27.5	24.8	24.9
TOTAL PLANT COVER	57.3	53.9	51.9	53.2

TABLE 3. Environmental parameters at Hilina Pali study site.

Community	Mixed grass-shrub 'ōhi'a woodland
Elevation	1009 m (3310 ft)
Mean annual rainfall	1500 mm (59 in)
Mean annual air temp.	17°C (62.6°F)
Soil	3-25 cm (1-10 in) deep, discontinuous shallow ash on pāhoehoe
Slope	None. Level ground with slight undulations.

TABLE 4. Assessment of firing.

Air temperature	24.5°C (76.1°F)
Percent relative humidity	34
Wind direction	ENE
Wind speed	3-5 knots (5.5-9.3 km/h)
Rate of fire spread	15.6 ft/min (4.8 m/min)
Maximum temperature generated by fire	890°C (1634°F) at understory crown (approx. 1 m [3 ft] above ground)
	650°C (1202°F) at ground level

LITERATURE CITED

Hawaii Volcanoes National Park. 1977. Fire management plan.

Kartawinata, K., and D. Mueller-Dombois. 1972. Phytosociology and ecology of the natural dry-grass communities on Oahu, Hawaii. Reinwardtia 8:369-494.

Mueller-Dombois, D. 1976. The major vegetation types and ecological zones in Hawaii Volcanoes National Park and their application to park management and research. Pages 149-161 *in* C.W. Smith, ed. Proceedings, First Conf. in Natural Science, Hawaii Volcanoes N. P. CPSU/UH (Univ. Hawaii, Botany Dept.)

Mueller-Dombois, D., and F.R. Fosberg. 1974. Vegetation map of Hawaii Volcanoes National Park (at 1:52,000). CPSU/UH Tech. Rep. 4 (Univ. Hawaii, Botany Dept.)

St. John, H. 1973. List and summary of the flowering plants in the Hawaiian Islands. Pacific Tropical Botanical Garden, Memoir Number 1, Lawai, Kauai, Hawaii. 519 pp.

Stone, B.C. 1959. Natural and cultural history report on the Kalapana Extension of Hawaii National Park. Vol. II. Natural History Report, Botany. Bernice P. Bishop Museum, Honolulu. 67 pp. (Mimeo.)

Vogl, R.J. 1969. The role of fire in the evolution of the Hawaiian flora and vegetation. Pages 1-60 *in* Proceedings, Annual Tall Timbers Fire Ecology Conf.

Vogl, R.J. 1974. Effects of fire on grasslands. Pages 139-194 *in* T.T. Kozlowski and C.E. Ahlgren, eds. Fire and ecosystems. Academic Press, Inc., N.Y.

ACKNOWLEDGEMENTS

The authors wish to thank Dr. C. W. Smith and Dr. S. Conant for their help in revision of the manuscript, and also Ms. Deborah Weiner for her assistance in revision and preparation of the manuscript. The graphics were drawn by Mr. T. Nakata whose work is greatly appreciated.

APPENDIX

List of species by families. Citation of plant names follows St. John (1973).

Status: X = Exotic, I = Indigenous, E = Endemic.

Scientific name	Common name	Status
GRAMINEAE		
Andropogon glomeratus (Walt.) BSP.	Bush beardgrass	X
Andropogon virginicus L.	Broomsedge	X
Melinis minutiflora Beauv.	Molassesgrass	X
CYPERACEAE		
Bulbostylis capillaris (L.) C.B. Clarke	. . .	X
Carex wahuensis C.A. Mey.	. . .	E
LILACEAE		
Dianella sandwicensis H. & A.	'Uki'uki	E
MYRICACEAE		
Myrica faya Ait.	Firetree	X
SAPINDACEAE		
Dodonaea sandwicensis Sherff	'a'ali'i	E
MYRTACEAE		
Metrosideros collina subsp. *polymorpha* (Gaud.) Rock	'ōhi'a-lehua	E
ERICACEAE		
Vaccinium reticulatum Sm.	'Ōhelo	E
EPACRIDACEAE		
Styphelia tameiameiae (Cham.) F.Muell.	Pūkiawe	E

APPENDIX (continued). List of species by families.

Status: X = Exotic, I = Indigenous, E = Endemic.

Scientific name	Common name	Status
RUBIACEAE		
Coprosma ernodeoides Gray	Kūkae-nēnē	E
COMPOSITAE		
Erigeron canadensis L. (*Conyxa parva* Cronq.)	Canada fleabane	X
Hypochaeris radicata	Gosmore	X
Railliardia ciliolata DC. (*Dubautia ciliolata* [DC.] Keck)	Na'ena'e	E
Sonchus oleraceus L.	Pua-lele	X