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13. ABSTRACT *(Maximum 200 words)*

A wildfire swept through the Kipuka Kalawamauna Endangered Plants Habitat Area (KKEPHA) at the Pohakuloa Training Area, Hawaii on 25 through 27 July 1994. About 65% of the area burned. The fire potentially could have impacted rare plant species (*Haplostachys haplostachya, Silene hawaiiensis, Silene lanceolata, Stenogyne angustifolia, Tetramolopium arenarium,* and *Zanthoxylum hawaiiense*) within the KKEPHA as well as native plant communities which serve as habitat for the taxa. A study was began to determine the impacts of the wildfire on the species and the vegetation. Existing vegetation plots established prior to the fire were used as preburn controls and monitored 6 months and 1 year following the fire. Standardized U.S. Army Land Condition-Trend Analysis Program (LCTA) methods were used. Recovery of rare plant populations was monitored at 1 month, 6 months, and 1 year following the fire. Photographic records were used to document recover. The fire significantly reduced above ground density, basal cover, and aerial cover of shrubs and herbaceous plants. *Silene lanceolata, Tetramolopium arenarium,* and *Zanthoxylum hawaiiense* were killed by the fire; while, *Haplostachys haplostachya, Silene hawaiiensis* and *Stenogyne angustifolia* were resprouting or regenerating from seed.

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Robin B. Stacy 25 Oct 95

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INTRODUCTION

Pohakuloa Training Area (PTA) comprises approximately 47,000 ha and is the largest military training facility in Hawaii. It is located in a high saddle surrounded by the volcanoes Mauna Loa, Mauna Kea, and Hualalai (Fig. 1). Approximately half of the installation is ordnance impact area (Fig. 2). Due to extensive rough topography much of the area is inappropriate for infantry training. PTA was established as a training area in 1956 and is used by the 25th Infantry Division (Light), U.S. Marine Corps, U.S. Army Reserve, Hawaii National Guard, and occasionally by foreign allied troops.

Precipitation at Bradshaw Army Airfield (north central portion of the installation) is 429 mm per year. The highest monthly precipitation is in the winter months (Nov-Feb) in conjunction with Kona storms (Fig. 3). Average annual temperature is 12.8 C with little monthly variation. The growing season at PTA is essentially year-round except for the months of June and July when inadequate soil moisture may limit plant growth. The climate at PTA is classified as cool tropical (upper montane to subalpine)(Loope & Scowcroft 1985). Elevation varies from 2,700 m along the southern edge to 1,200 m in the northwestern corner of the installation.

Typically, the soils at PTA are poorly developed and shallow. Much of the area is classified as cinder lands, a'a and pahoehoe lava flows, rocklands, and very stony lands (USDA 1973). Four soil subgroups are represented at PTA: Typic and Mollic Vitradepts, and Typic and Lithic Tropofolists.

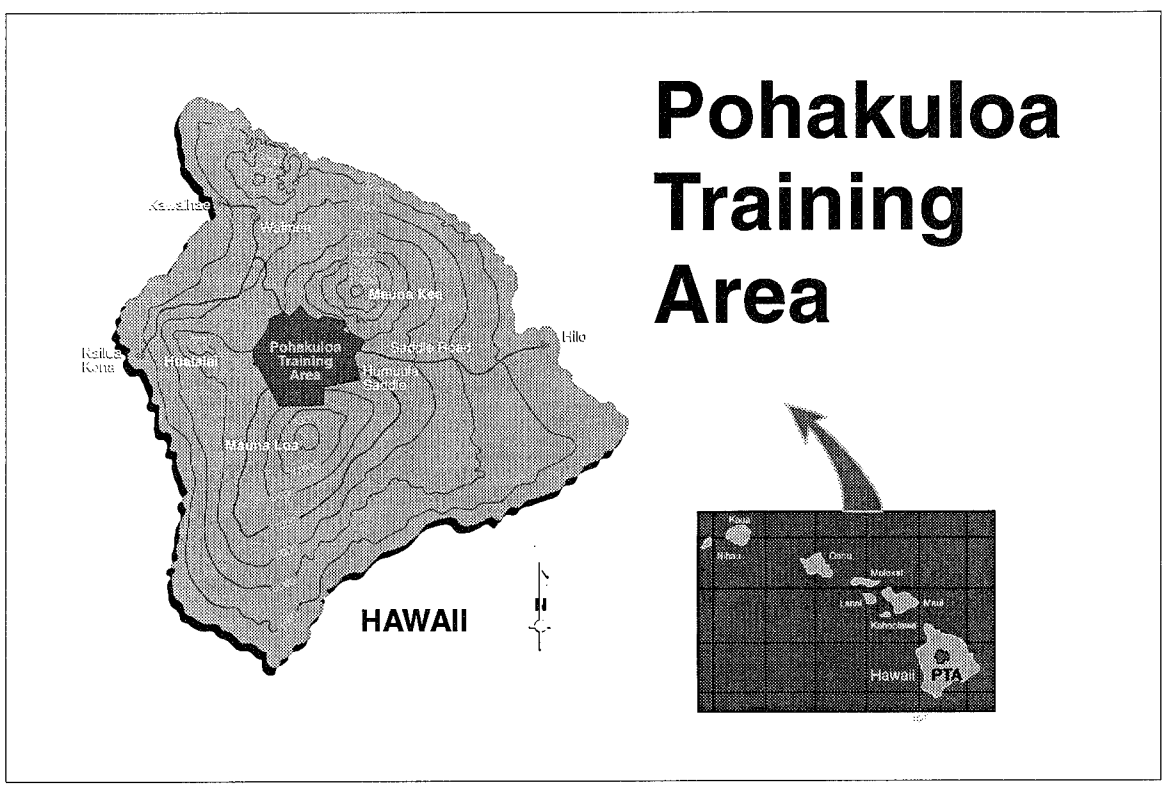

Figure 1. Location of Pohakuloa Training Area on the Island of Hawaii, Hawaii.

Figure 2. Map of the Pohakuloa Training Area, Hawaii showing extent of impact area and location of the Kipuka Kalawamauna Endangered Plants Habitat Area (KKEPHA).

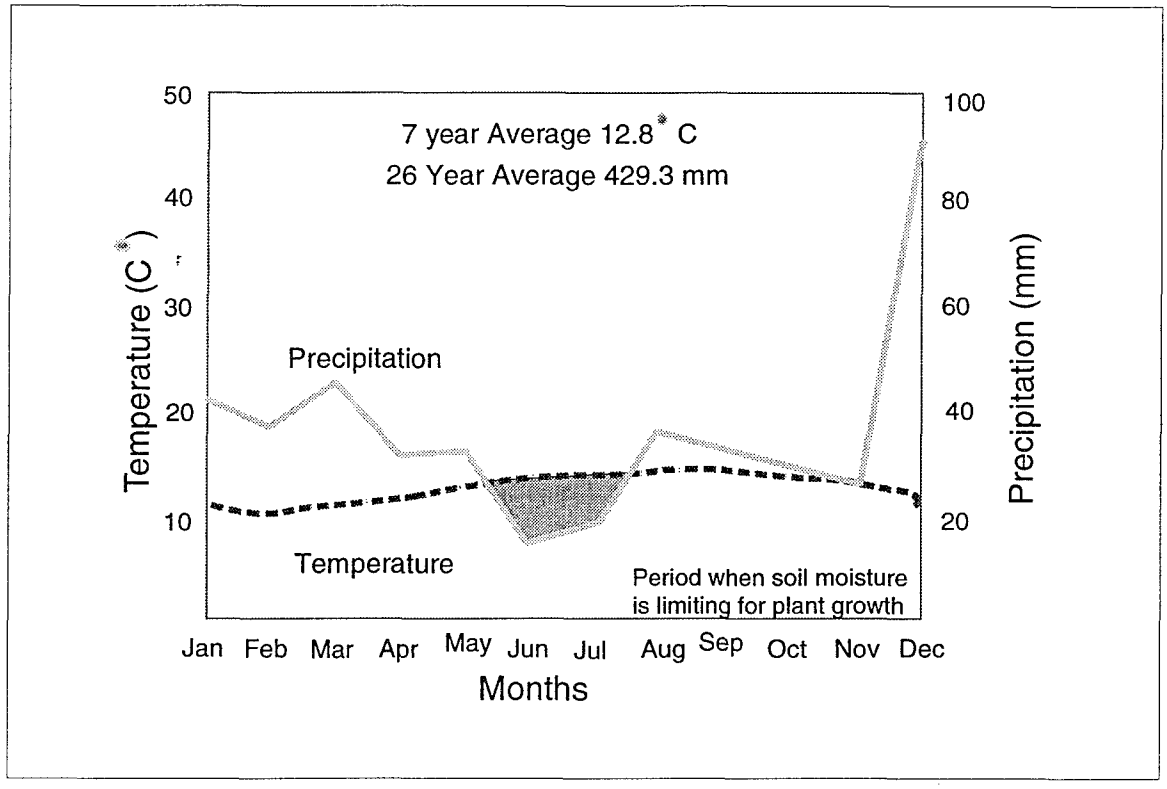

Figure 3. Climatic diagram for Pohakuloa Training Area, Hawaii. The shaded area indicates the period when soil moisture is limiting for plant growth.

The vegetation at PTA is composed of dry montane and subalpine grassland, shrubland, and forest communities. Based on the Gagne and Cuddihy classification of Hawaiian plant communities presented in Wagner et al. (1990), the following montane and subalpine types are found on PTA: 1. *Eragrostis/Panicum* Grassland; 2. *Dodonaea* Montane Shrubland; 3. *Metrosideros/Dodonaea* Shrubland; 4. *Metrosideros* Montane Dry Forest; 5. *Chamaesyce* Forest; 6. *Dodonaea/Vaccinium/Styphelia* Shrubland; 7. *Styphelia/Vaccinium* Shrubland; 8. *Chenopodium* Subalpine Shrubland; 9. *Sophora* Forest; and 10. *Metrosideros* Subalpine Forest.

The vegetation of PTA is important because it represents some of the less disturbed dry montane forests, shrublands, and grasslands remaining on the island of Hawaii. Also, much of the surrounding land has been used for livestock grazing and residential development and little native dryland vegetation remains. Although PTA has been used for military training since the 1950's, a preliminary summary of land condition at the installation indicated that approximately 4% of PTA outside of the ordnance impact area has been disturbed by military training (Shaw et al. 1990). Disturbance by feral pigs, sheep, and goats and competition by alien species are the greatest threats to the native vegetation at PTA.

A floristic survey of the installation has identified a total of 248 plant species, 178 genera, and 68 families (Shaw & Douglas 1995). Naturalized and/or alien species account for 60% of the species on the installation, and 40% of the species are indigenous or endemic. Approximately 65% of the taxa are perennial, while the remaining 35% are annual or biennial.

Seventeen rare plant species occur on the installation. There are ten federally listed endangered species [*Asplenium fragile* K. Presl var. *insulare* Morton, *Haplostachys haplostachya* (A. Gray) St. John, *Hedyotis coriacea* Sm., *Portulaca sclerocarpa* A. Gray, *Silene lanceolata* A. Gray, *Stenogyne angustifolia* A. Gray, *Speremolepis hawaiiensis* Wollf, *Tetramolopium arenarium* (A. Gray) Hillebr., *Tetramolopium lepidotum* (Less.) Sherff, and *Zanthoxylum hawaiiense* Hillebr.], one federally listed threatened species (*Silene hawaiiensis* Sherff), and six candidate species [*Chamaesyce olowaluana* (Sherff) Croizat & Degener , *Eragrostis deflexa* Hitchc., *Exocarpos gaudichaudii* A. DC, *Festuca hawaiiensis* Hitchc., *Portulaca villosa* Cham., and *Tetramolopium consanguineum* (A. Gray) Hillebr.]. An endangered plants habitat area encompassing Kipuka Kalawamauna (KKEPHA) was designated cooperatively by the U.S. Army, U.S. Fish & Wildlife Service, and State of Hawaii for the protection of some of these species (Fig. 2). KKEPHA is an approximately 2,750 ha older Mauna Kea lava flow surrounded by newer, sparsely vegetated, or barren Mauna Loa lava flows.

During the late evening of 24 July 1994 or early morning of 25 July 1994 a wildfire began in rangeland westsouthwest of PTA and the KKEPHA. Lightning has been suggested as the most likely cause of the fire. By noon of 25 July the fire had crossed the installation boundary and proceeded into the KKEPHA (Fig. 4). Twenty-four hours later approximately 25% of the KKEPHA had burned. Federal, state, county, and private crews fought the wildfire with heavy machinery and helicopter operations. By mid-afternoon on 27 July the

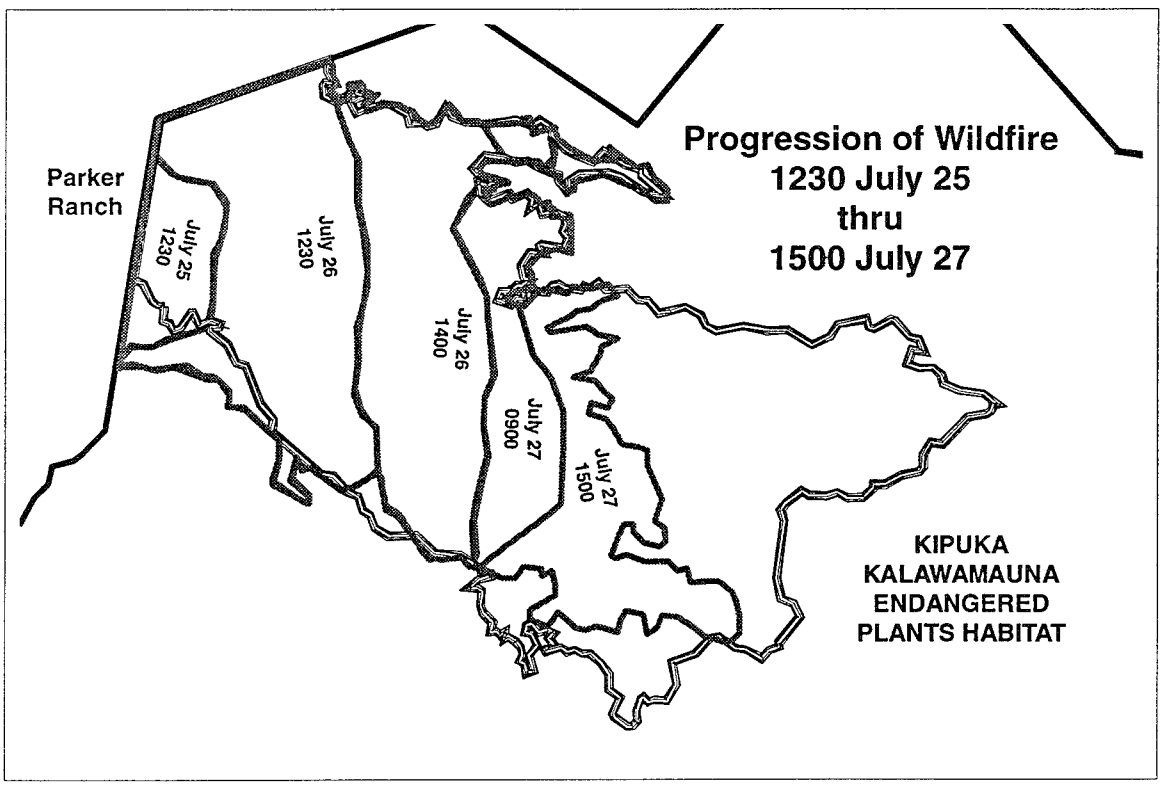

Figure 4. Map of the Kipuka Kalawamauna Endangered Plants Habitat Area (KKEPHA) on Pohakuloa Training Area, Hawaii showing the progress and extent of the wildfire of July 1994.

main advance of the fire was halted after consuming approximately 65% (1785 ha) of the KKEPHA. The fire, which continued to smolder and occasionally flare-up, was finally extinguished in late August.

The objectives of this paper are to: (1) characterize the wildfire, (2) describe the impact of the wildfire on the major vegetation types within the Kipuka, and (3) describe the wildfire effects on the endangered and threatened plant species within the Kipuka.

BODY

METHODS

Fire Characteristics (Romero 1995):

Estimation of fire severity was difficult for the Kipuka Kalawamauna fire for several reasons. First, flame lengths were not measured during the burn. Second, severity analysis was not begun until February 1995, and post-burn ground characteristics could not be accurately determined. Thus, to complete fire severity analysis, it was necessary to sample the vegetation in adjacent unburned areas which most resembled the burned areas. These data from the unburned area would be used to make a set of custom fuel models for use in the BEHAVE fire behavior prediction system (Andrews 1986).

Fuel load plots were randomly located within the unburned portions of the two dominant vegetation types with the KKEPHA [*Dodonaea* (2 plots) and *Myoporum* (4 plots) communities] delineated by Castillo et al. (1995). At each plot the woody dead and down

fuels along with litter, duff, herbaceous and shrub cover were inventoried following the methods described by Brown et al. (1982). Litter and herbaceous fuel samples were collected and dried at 90 C for 24 hours to determine oven-dry weights. Computed fuel loads and cover data were used in Burgan and Rothermel (1984) NEWMODEL to create custom fuel models. The information from NEWMODEL was then used in the FIRE1 module of Andrews (1986) of the BEHAVE system to produce the fire behavior estimates needed to determine fire severity. Weather information gathered from Bradshaw Army Airfield [6 miles (10 km) northeast of the Kipuka] was used to determine fuel moisture values. The fuel moisture values used in making the fire behavior predictions were 5-5.2%, 7-7.2%, and 9-9.2% for 1 hour, 10 hour, and 100 hour fuel moisture, respectively. Results from the model were verified by observations on road surveys within the burn area and by interviews with researchers and fire fighters who witnessed the wildfire.

Impacts on Vegetation:

The condition of the vegetation and training lands at PTA were initially surveyed in 1989 using the U.S. Army's Land Condition-Trend Analysis Program (LCTA)(Shaw et al. 1990, Diersing et al. 1992). Fourteen of the original LCTA plots were within the burned area. Nine of the plots were *Dodonaea* dominated shrublands and 5 plots were in *Myoporum* shrublands. Basal and foliar cover by species and woody plant density and height were determining in the initial inventory and monitored again in 1993. Military and non-military

disturbance also was determined for each of the plots. Plots were resurveyed 6-months and 1-year following the wildfire. A photographic record of the plots prior to burning, 1-month, 6-months, and 1-year following the fire are in Appendix Figures 1-14.

Impacts on Rare Plants:

Impacts of the wildfire on endangered and threatened plant species are based on field observations immediately following the event and during photographing and resampling of the LCTA plots 1-month, 6-months, and 1-year after the fire. Seedling recruitment and vegetative resprouting was recorded at 6-months and 1-year postburn. Taxa evaluated were *Haplostachys haplostachya, Silene hawaiiensis, Silene lanceolata, Stenogyne angustifolia, Tetramolopium arenarium,* and *Zanthoxylum hawaiiense.*

RESULTS & DISCUSSION

Fire Severity (Romero 1995):

Output from the BEHAVE Fire behavior prediction system (Andrews 1986) include flame length and heat per unit area. Flame length is used as an indicator of upward heat release, while heat per unit area is a measure of the total amount of heat released within a given area during the passage of the flame front as well as during the smoldering or glowing stages of combustion. Absorption of heat within the soil is a function of the insulating characteristics of the soil, the length of time the soil is exposed to heat, and the total amount of

heat produced during flaming/smoldering/glowing combustion. Heat per unit area is useful in making inferences about the downward heat pulse.

Estimated flame lengths ranged from 3.5 m to 4.0 m depending on degree of slope within the *Dodonaea viscosa* Jacq. dominated community type. The *Myoporum sandwicense* A. Gray dominated community had flame lengths approximately one-half of those of the other major shrub community. Estimated flame lengths ranged from 1.7 m to 2.0 m depending on degree of slope within the *Myoporum* community. These results from the BEHAVE simulations agreed with field observations. The average heights of charred branchwood on remnant shrubs were between 1.2 m and 2.0 m, with some taller shrubs were charred up to 3 m. Some shrubs still retained leaves, flowers, fruits and branchwood (<5 cm in diameter) which indicated the upward pulse was not severe. Also, the dominant grasses in the area [*Eragrostis atropioides* Hillebr. and *Pennisetum setaceum* (Forssk.) Chiov.] were typically burned down to a height of 5 to 8 cm, with the root crown undamaged, and in most instances regrowth was occurring.

Predicted heat per unit area estimates were 1039 btu/ft2 for the *Dodonaea* community and 1142 btu/ft2 for the *Myoporum* community. Dead and down woody fuel particles >0.5 cm (10 hour lag fuels) could still be found and particles > 7.5 cm (100 hour lag fuels) were mostly unburned which agreed with the prediction of a low to moderate heat per unit area.

The highest upward heat pulse occurred in the *Dodonaea* dominated shrublands with estimated flame lengths of over 3.0 to 4.0 m. The *Myoporum* shrublands had slightly shorter

estimated flame lengths (<2 m) but had a greater output of downward heat. Fire severities within the Kipuka Kalawamauna could be classified as low to moderate depending upon degree of slope. For comparison, these results can be compared with fire behavior predictions from better known temperate plant community types. Shortgrass steppe types typically have low severity fires. Given similar fuel moisture and wind conditions, shortgrass steppe simulations have flame lengths of about 2.1 m and heat per unit area of 90 btu/ft2. Conversely, heavy logging slash typically has high severity fires. Under similar wind and moisture conditions, logging slash fires would have flame lengths exceeding 4.0 m and heat per unit area of 3200 btu/ft2.

Impacts on Vegetation

Results of the wildfire on the Kipuka Kalawamauna vegetation were analyzed and reported based on the two dominant community types within the area (e.g. 9 plots representing *Dodonaea* community types and 5 plots representing *Myoporum* community types).

Dodonaea Community Types:

Absolute Shrub Density: Prior to the wildfire of July 1994 the *Dodonaea* communities had an average of 8335 woody stems/ha. Dominant species were *Dodonaea viscosa* (3140 stems/ha), *Chenopodium oahuense* (Meyen) Aellen (1767 stems/ha), and miscellaneous taxa [*Bidens minziesii* (A. Gray) Sheriff, *Chamaesyce multiformis* (Hook. & Arnott) Croizat & Degener, *Dubautia linearis* (Gaud.) D. Keck, *Sida fallax* Walp., *Santalum ellipticum* Gaud.

(with a total of 3334 stems/ha)](Figure 5). *Myoporum sandwicense* was uncommon in these community types (< 100 stems/ha). Six months following the fire woody stem density in these areas had decreased to 1567 stems/ha, and *Dodonaea* (1400 stems/ha) constituted nearly 90% of the total. Shrub density continued to decline one year following the fire to only 1050 stems/ha. *Dodonaea* comprised only 80% of the stem density (850 stems/ha) one year following the burn (Figure 5).

Absolute Shrub Aerial Cover: Total absolute above ground shrub cover was 18% prior to the July 1994 wildfire. *Dodonaea* constituted approximately 75% of the shrub cover (~14%), while *Chenopodium oahuense* and the other category each amounted to about 10% (~2%) of the cover (Figure 6). Total absolute shrub cover 6 months and 1 year following the fire decreased to about 4% and 5%, respectively. After the fire, *Dodonaea* continued to dominate the shrub cover category (65% and 85% 6 months and 1 year following the fire, respectively). Other shrubs have shown only slight recovery in above ground cover.

Absolute Herbaceous Basal Cover: Total absolute herbaceous basal cover was approximately 7% prior to the burn. The introduced grass, *Pennisetum setaceum,* accounted for about 5% of the basal cover (Figure 7). The dominate native grass species was *Eragrostis atropioides* (<0.25%). The Other category was predominantly *Lepidium hyssopifolium* Desv. *L. virginicum* L., and *Rhynchelytrum repens* (Willd.) Hubb. One year following the fire basal cover of *P. setaceum* had been reduced to <2%, while *E. atropioides* had returned to its preburn cover (Figure 7).

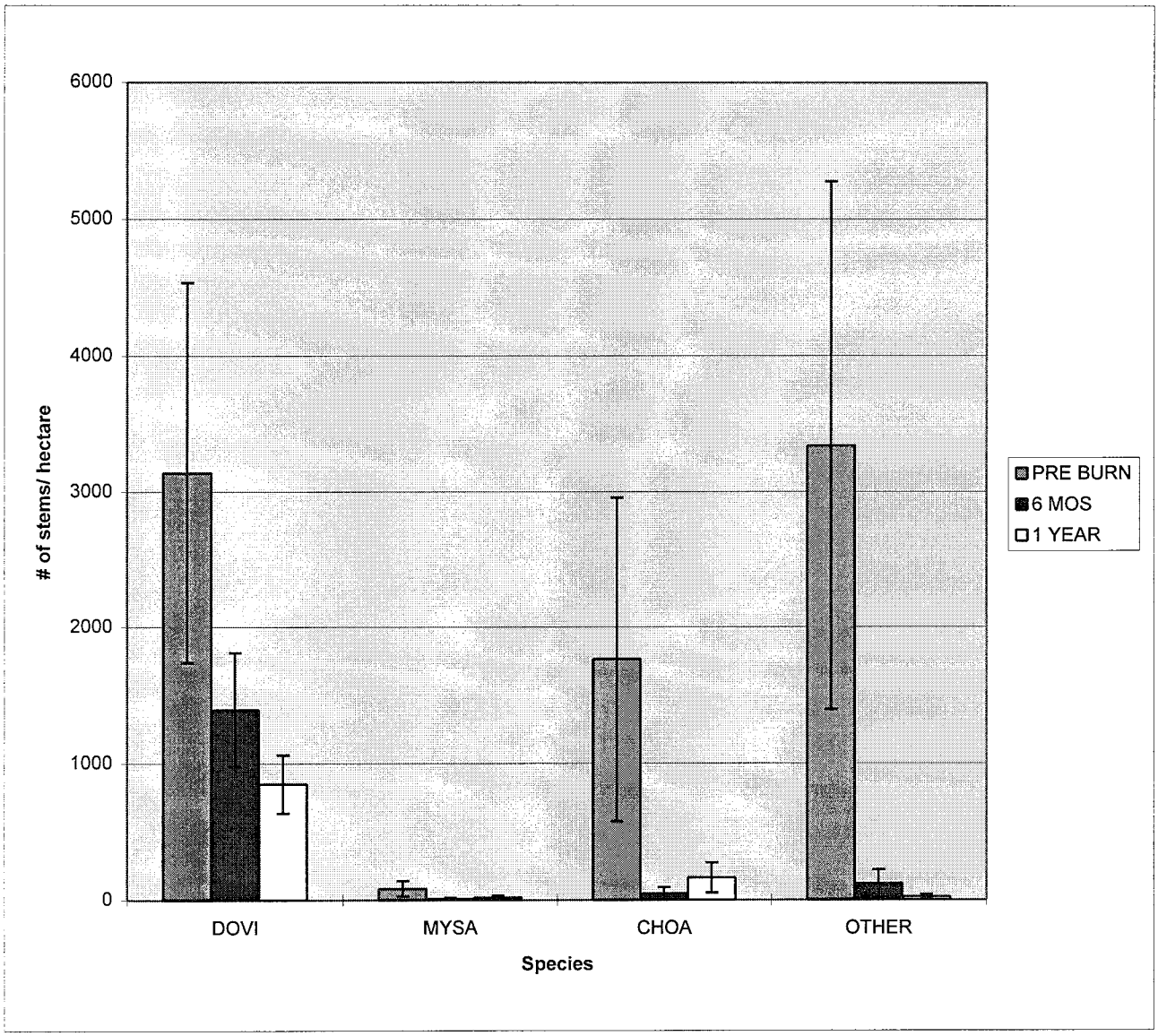

Figure 5. Mean woody plant densities for nine *Dodonaea* dominated vegetative plots prior to, 6 months and 1 year following the July 1994 wildfire in the Kipuka Kalawamauna Endangered Plants Habitat Area, Pohakuloa Training Area, Hawaii (DOVI=*Dodonaea viscosa,* MYSA=*Myoporum sandwicense,* CHOA=*Chenopodium oahuense*).

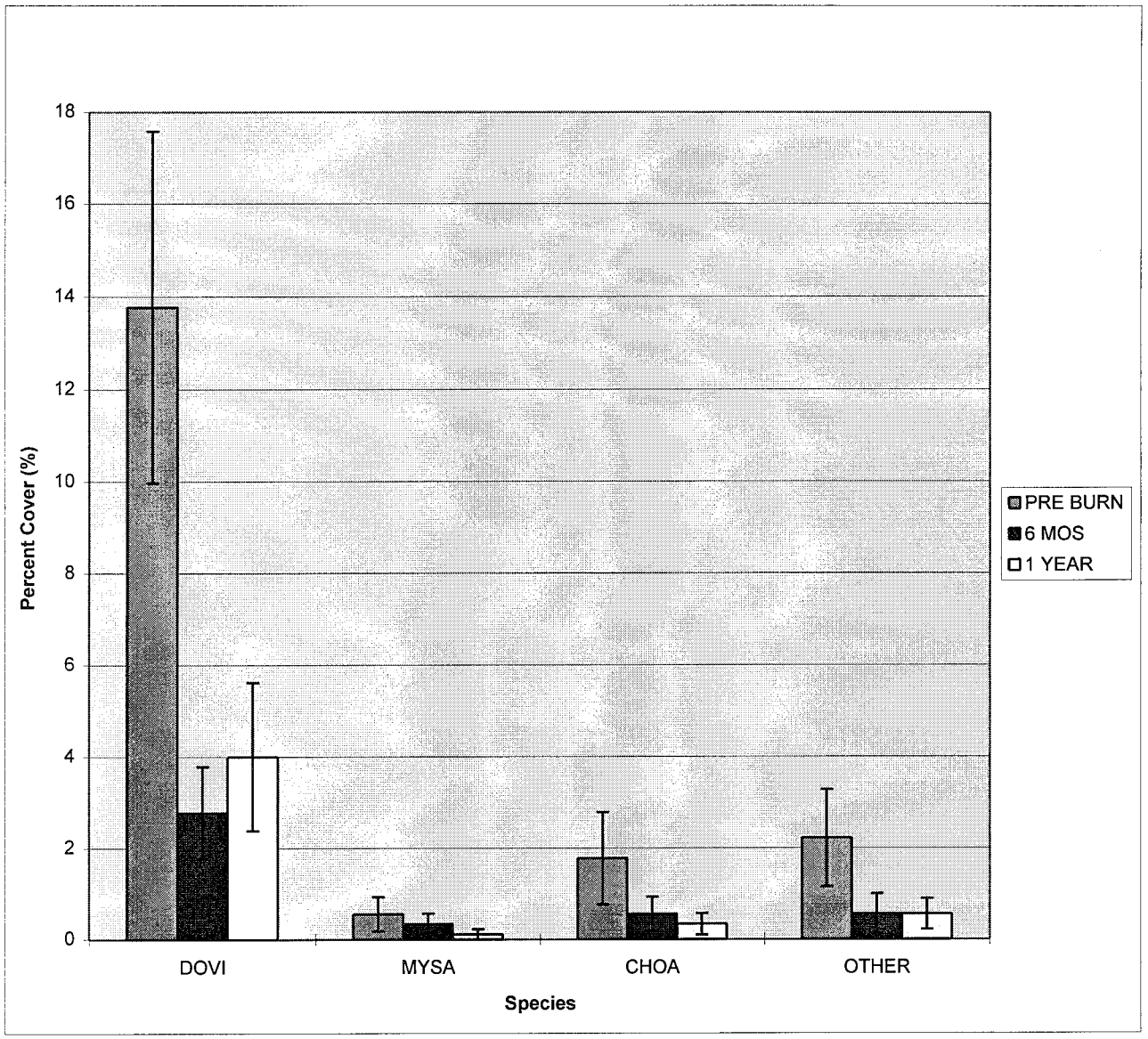

Figure 6. Mean woody plant aerial cover for nine *Dodonaea* dominated vegetative plots prior to, 6 months and 1 year following the July 1994 wildfire in the Kipuka Kalawamauna Endangered Plants Habitat Area, Pohakuloa Training Area, Hawaii (DOVI=*Dodonaea viscosa,* MYSA=*Myoporum sandwicense,* CHOA=*Chenopodium oahuense*).

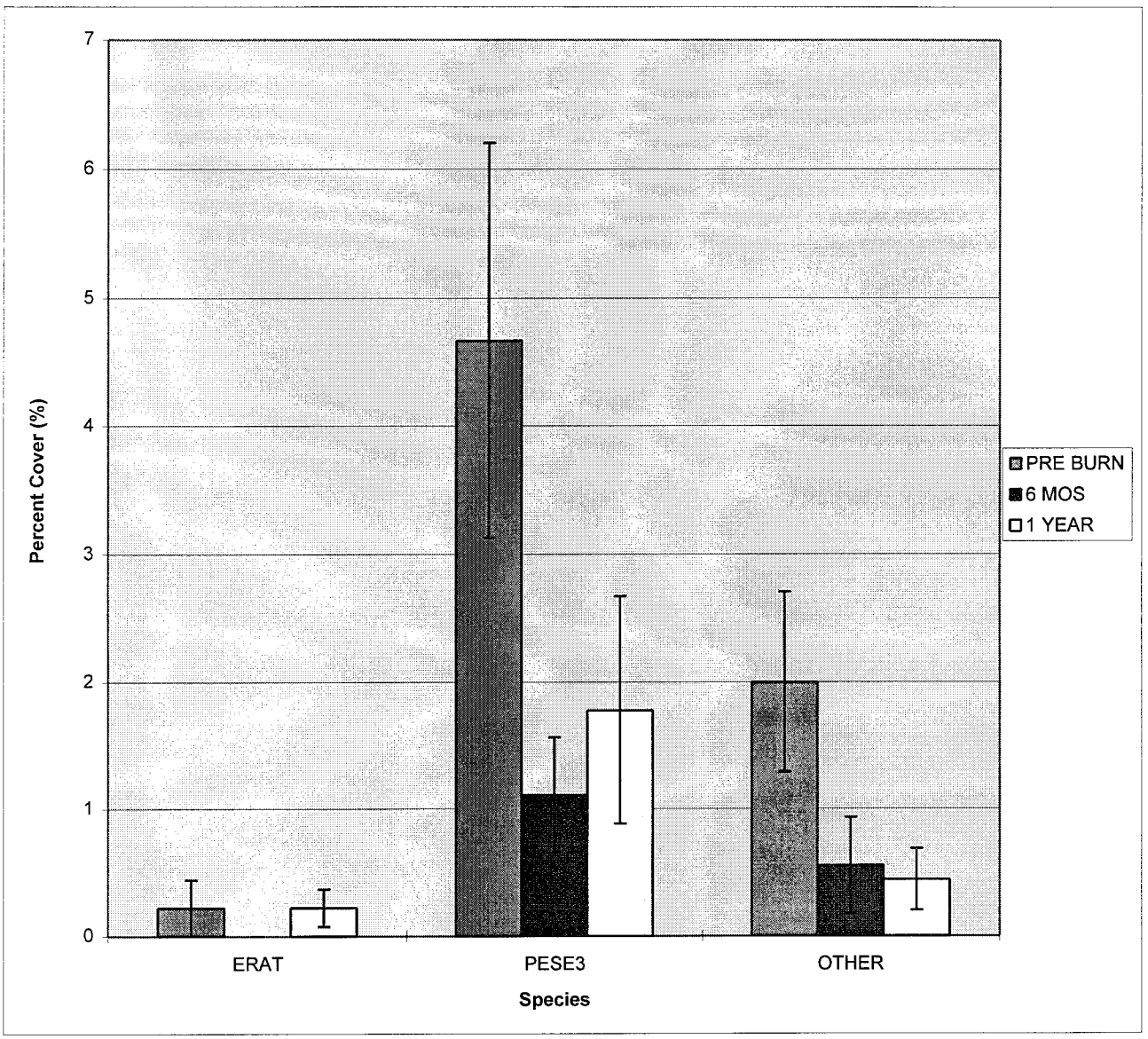

Figure 7. Mean herbaceous plant basal cover for nine *Dodonaea* dominated vegetative plots prior to, 6 months and 1 year following the July 1994 wildfire in the Kipuka Kalawamauna Endangered Plants Habitat Area, Pohakuloa Training Area, Hawaii (ERAT=*Eragrostis atropioides,* PESE3=*Pennisetum setaceum*).

Absolute Herbaceous Aerial Cover: Total absolute herbaceous aerial cover was 84% prior to the burn, and *Pennisetum setaceum* was the dominant (46%). *Eragrostis atropioides* was the dominant native grass species (~ 9%)(Figure 8). One year following the fire *P. setaceum* aerial cover was reduced to nearly one-half of the preburn value, while *E. atropioides* aerial cover exceeded the preburn value. The Other category, constituted primarily of exotic species, has shown little recovery.

Myoporum Community Types:

Absolute Shrub Density: Prior to the wildfire of July 1994 the *Myoporum* communities had an average of 2417 woody stems/ha. Dominant species were *Dodonaea viscosa* (1100 stems/ha), *Myoporum sandwicense* (516 stems/ha), and miscellaneous taxa [*Chamaesyce multiformis*, *Dubautia linearis*, *Sida fallax*, and *Santalum ellipticum* Gaud. (with a total of 733 stems/ha)](Figure 9). Six months following the fire, total woody stem density had decreased to 723 stems/ha, and *Dodonaea* (616 stems/ha) constituted nearly 85%. Shrub density continued to decline one year following the fire to only 640 stems/ha. *Dodonaea* and the Other shrub category continued to decrease in density one year following the fire; however, *Myoporum* showed a significant increase from 10 stems/ha 6 months following the fire to 166 stems/ha 1 year following the fire.

Absolute Shrub Aerial Cover: Total absolute above ground shrub cover was 20% prior to the July 1994 wildfire. *Myoporum* constituted approximately 9% of the shrub cover ,

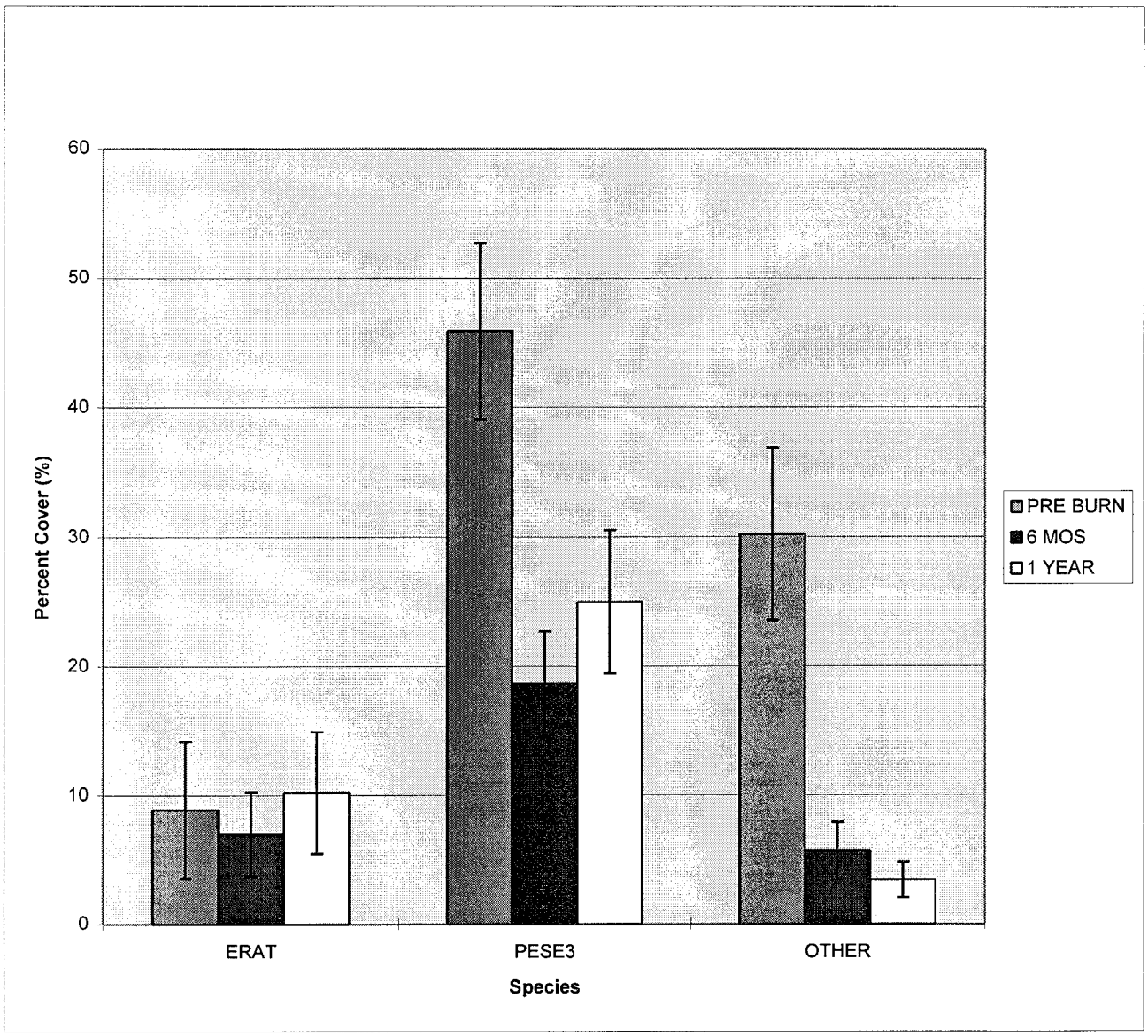

Figure 8. Mean herbaceous plant aerial cover for nine *Dodonaea* dominated vegetative plots prior to, 6 months and 1 year following the July 1994 wildfire in the Kipuka Kalawamauna Endangered Plants Habitat Area, Pohakuloa Training Area, Hawaii (ERAT=*Eragrostis atropioides*, PESE3=*Pennisetum setaceum*).

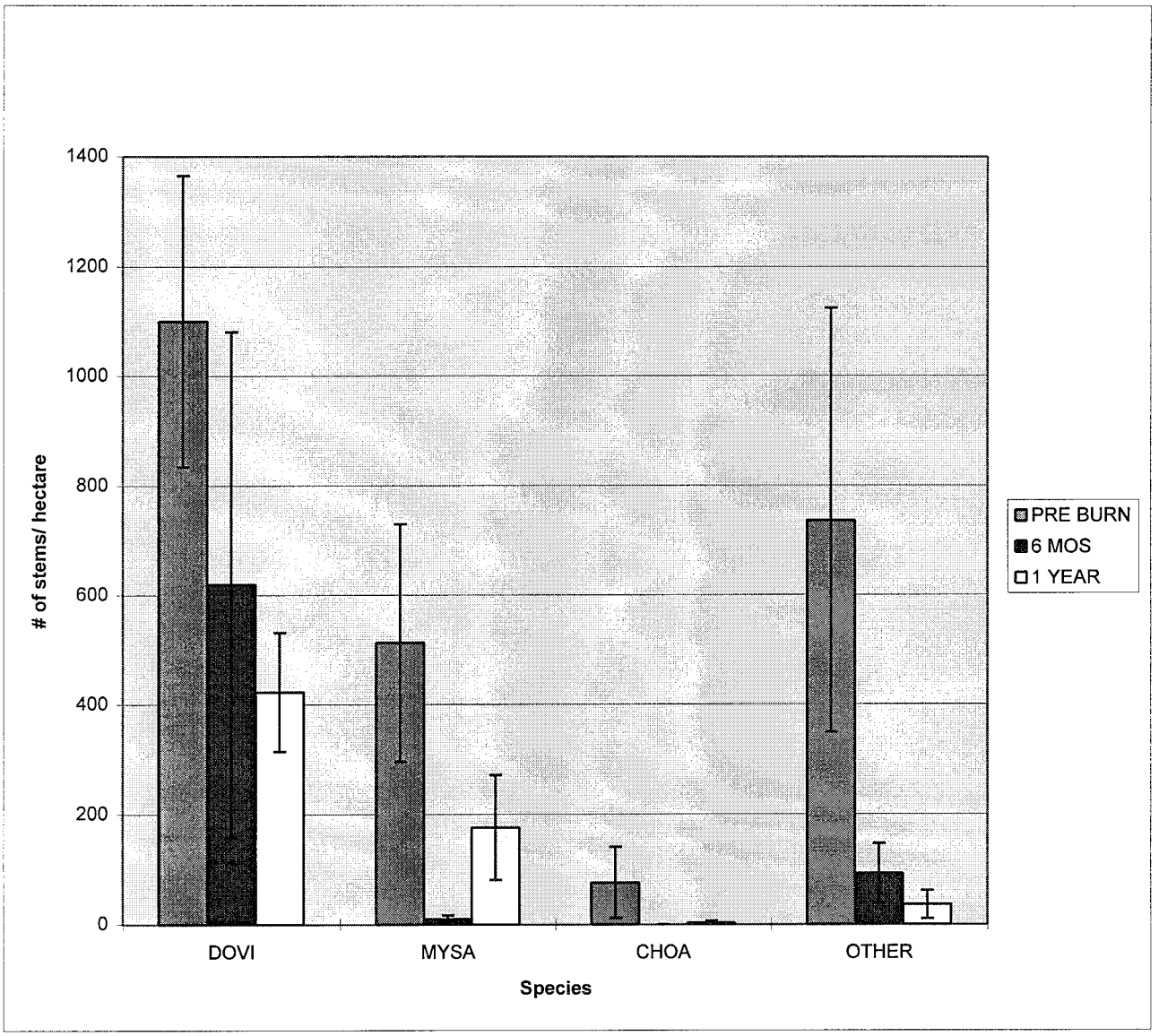

Figure 9. Mean woody plant densities for five *Myoporum* dominated vegetative plots prior to, 6 months and 1 year following the July 1994 wildfire in the Kipuka Kalawamauna Endangered Plants Habitat Area, Pohakuloa Training Area, Hawaii (DOVI=*Dodonaea viscosa,* MYSA=*Myoporum sandwicense,* CHOA=*Chenopodium oahu*ense).

while *Dodonaea* composed about 8%of the cover (Figure 10). Total absolute shrub cover 6 months and 1 year following the fire decreased to about 5% and 3%, respectively. After the fire, *Dodonaea, Myoporum* and the Other shrub category each had aerial cover of less than 2%.

Absolute Herbaceous Basal Cover: Total absolute herbaceous basal cover was approximately 7% prior to the burn, and the introduced grass, *Pennisetum setaceum,* accounted for 6% of the basal cover (Figure 11). The other category was predominantly *Eragrostis leptophylla* Hitchc., *Senecio mikanioides* Otto ex Walp., and *Rhynchelytrum repens*. The fire reduced basal cover of *P. setaceum* to 2%.

Absolute Herbaceous Aerial Cover: Total absolute herbaceous aerial cover was 96% prior to the burn, and *Pennisetum setaceum* was the dominant (78%). *Eragrostis atropioides* cover was insignificant in the *Myoporum* community prior to the fire (Figure 12). Following the fire *P. setaceum* aerial cover was reduced to less than one-half of the preburn value. The Other category, composed primarily of exotic species, showed little recovery.

Impacts on Rare Plants:

Haplostachys haplostachya is a perennial subshrub belonging to the mint family (Lamiaceae). It is the last remaining extant member of the genus and is only found at PTA and the Parker Ranch. Shaw (1995) estimated that more than 20,000 individuals of this species occur in the area. It is federally listed an endangered species. Approximately 25% of

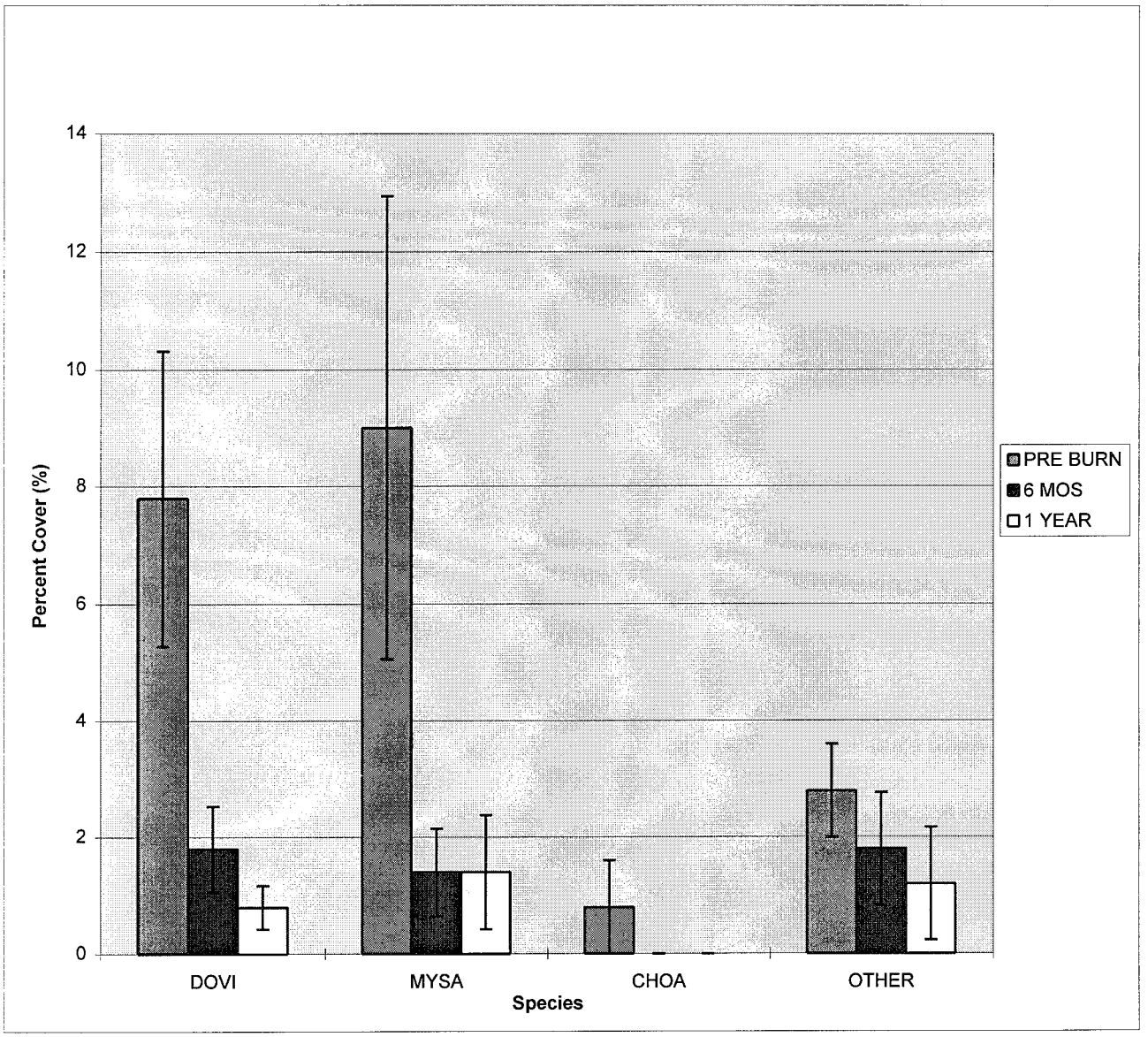

Figure 10. Mean woody plant aerial cover for five *Myoporum* dominated vegetative plots prior to, 6 months and 1 year following the July 1994 wildfire in the Kipuka Kalawamauna Endangered Plants Habitat Area, Pohakuloa Training Area, Hawaii (DOVI=*Dodonaea viscosa,* MYSA=*Myoporum sandwicense,* CHOA=*Chenopodium oahuense*).

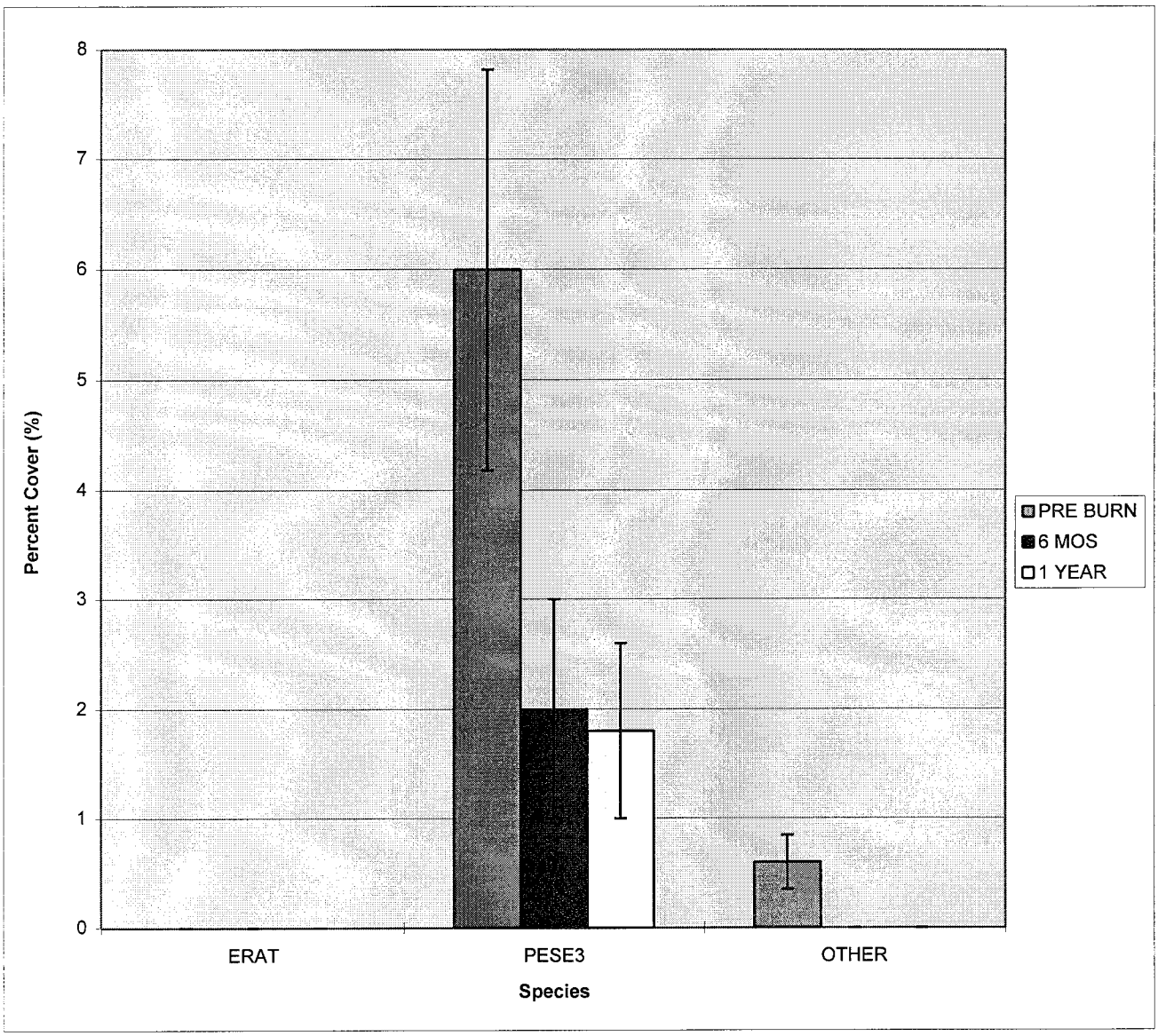

Figure 11. Mean herbaceous plant basal cover for five *Myoporum* dominated vegetative plots prior to, 6 months and 1 year following the July 1994 wildfire in the Kipuka Kalawamauna Endangered Plants Habitat Area, Pohakuloa Training Area, Hawaii (ERAT=*Eragrostis atropioides*, PESE3=*Pennisetum setaceum*).

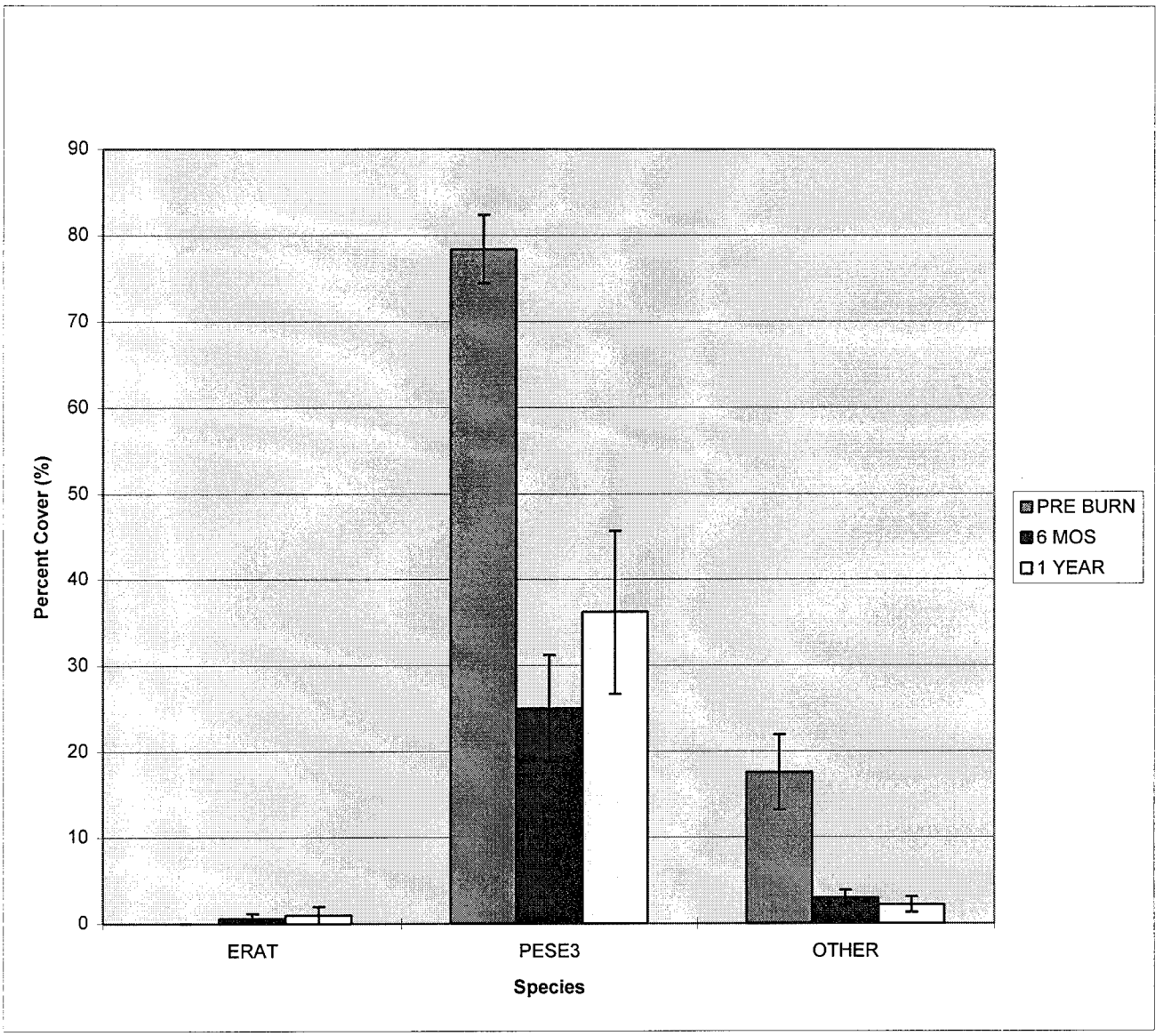

Figure 12. Mean herbaceous plant aerial cover for five *Myoporum* dominated vegetative plots prior to, 6 months and 1 year following the July 1994 wildfire in the Kipuka Kalawamauna Endangered Plants Habitat Area, Pohakuloa Training Area, Hawaii (ERAT=*Eragrostis atropioides,* PESE3=*Pennisetum setaceum*).

the known populations of this species were impacted by the wildfire of July 1994 or the ensuing attempts at controlling the fire (e.g. cutting fire lines). The species response to the disturbance varied based upon the severity of the fire. In lightly burned areas or when the plants were only scorched by the heat, individuals resprouted from the root crown as soon as sufficient precipitation occurred. *Haplostachys* individuals were killed in slightly or moderately burned areas. Seedlings, however, were observed in all the vicinity of known populations several months after the fire. The substantial precipitation that occurred two months following the fire (September, Table 3) seemed to enhance resprouting as well as seed germination. Intense browsing of new seedlings and resprouts by feral sheep and/or goats severely inhibited the recovery of this species.

Silene hawaiiensis is a perennial shrub or subshrub with a large tuberous taproot. It is a member of the Caryophyllaceae (Pink Family). The species has a relatively wide distribution on the installation and elsewhere on the island of Hawaii. Shaw (1995) estimated that over 1500 individuals of *S. hawaiiensis* occur on PTA. The taxon is federally listed as threatened. The Kipuka fire impacted only one of over 25 populations of the species on the installation. *Silene hawaiiensis* immediately resprouted from its large fleshy taproot and appeared to flourish following the fire. No seedlings of the species were observed in the area following the fire. The species is relished by feral animals and is readily consumed when they locate plants; however, the sheep and/or goats had not found the resprouting plants within the Kipuka Kalawamauna.

Silene lanceolata is a single-stemmed, sprawling shrub that grows to about 1.5 m tall. It also is a member of the pink family (Caryophyllaceae). The plant is known only from PTA, a small population on Molokai, and a single individual on Oahu (Wagner et al 1990). The largest populations are found on PTA, and over 2500 individuals are thought to occur on the installation (Shaw 1995). The species is federally listed as endangered. The Kipuka fire impacted less than 10% of the total number of individuals at PTA. Plants that were completely consumed by the fire did not resprout; however, plants that were only heat scorched lost their leaves and smaller branches but did resprout. No *S. lanceolata* seed germination or seedling establishment was observed in the area following the fire. Similar to *S. hawaiiensis,* feral sheep and goats relish the plant and will readily consume any plant they locate, and browsing of some of the recovering *S. lanceolata* plants was observed.

Stenogyne angustifolia is a rhizomatous and stoloniferous perennial plant. It also belongs to the mint family (Lamiaceae) and is found over much of the west side of PTA and at several locations off the installation. Shaw (1995) has estimated that there are well over 100,000 individuals of this species. It is federally listed as an endangered species. The wildfire possibly impacted between 25% and 45% of the existing populations of *S. angustifolia.* Regardless of the severity of the fire, *S. angustifolia* resprouted from underground root crowns or rhizomes. Also, seedlings abounded in areas previously know to support the species soon after substantial precipitation fell following the burn (September).

Similar to *Haplostachys haplostachya*, *S. angustifolia* recovery from the fire was severely impacted by browsing by feral sheep and/or goats.

Tetramolopium arenarium is a short-lived, erect shrub that can grow to 2 m in height. It belongs to the sunflower family (Asteraceae) and was thought to be extinct until its recent rediscovery within the Kipuka Kalawamauna (Douglas et al. 1989). There are currently two known populations within the Kipuka which support over 500 individuals (Shaw 1995). It is federally listed as an endangered species. The fire of July 1994 nearly consumed one of the two populations. Fire severity in the area where the species occurs was low; however, the shrubs were killed and no resprouting was observed. Seed germination and seedling establishment of *T. arenarium* was not observed until 9 month following the fire (January 1995). No browsing by feral sheep and/or goats has been observed on this species.

Zanthoxylum hawaiiense is a small tree of 1 to 8 m in height. It belongs to the citrus family (Rutaceae). The species is restricted to the leeward side of most of the Hawaiian Islands. On PTA a few hundred individuals have been found along the west side of the installation growing primarily in ohia forest. There were a total of four trees within the Kipuka which are the only trees known to exist outside of forested areas.. The species is federally listed as endangered. The fire completely consumed the four plants, and no resprouting was observed from any of the stumps. Also, no seedlings of *Z. hawaiiense* have been found in the area where the plants occurred prior to the fire.

CONCLUSIONS

The Kipuka Kalawamauna Endangered Plants Habitat Area was established cooperatively by the U.S. Army, State of Hawaii, and U.S. Fish & Wildlife Service to protect federally listed endangered species as well as their habitat. Not only do a large number of rare plant species occur within the boundaries of the Kipuka, but some of most pristine and last remaining tropical, montane shrublands and grasslands also occur in the area. The wildfire that occurred in July 1994 severely impacted the rare plant species. The impacts, however, were more severe to the plant communities that support the species than to the rare plants themselves. The severity of the wildfire that swept through the Kipuka was classified as low to moderate, with flame lengths of around 3 to 4 m and a downward heat pulse of between 1000 and 1300 btu/ft2. The initial visual impacts of the fire, however, appeared severe (see appendix figures for photographic record). After substantial precipitation (~ 6.5 cm) two months following the fire, regrowth of the dominant species began to take place. *Dodonaea viscosa,* particularly, began to vigorously sprout, and density of this species 6 months after the fire was close to half of preburn values. However, by the next sample period (July 1996, 1 year following the burn) *D. viscosa* had further declined to only about a third of the original density. This further decrease in *D. viscosa* is interpreted as the result of increased moisture stress induced by the beginning of the dry season (June - August). *Myoporum sandwicense, Chenopodium oahuense,* and other shrubby species showed little recovery.

As expected, the initial impact of the wildfire on the herbaceous vegetation was complete removal of nearly all standing biomass. *Pennisetum setaceum,* the dominant grass species in the communities which also is considered a noxious alien plant, decreased significantly in basal and aerial cover. One year following the fire basal cover had only returned to about one-third of the preburn values, while aerial cover had returned to about one-half of the preburn cover. *Eragrostis atropioides*, the dominant native grass species, had recovered to the preburn basal cover and surpassed the preburn aerial cover values within the *Dodonaea* community types. It is anticipated that *P. setaceum* will continue to increase in both basal and aerial cover and ultimately surpass its original dominance of the sites. Several areas within the Kipuka that have been repeatedly burnt have developed into fire maintained, monocultures of *P. setaceum.*

The impact of the wildfire on endangered plant species varied. Woody plant species were severely damaged. Individuals of *Tetramolopium arenarium, Silene lanceolata,* and *Zanthoxylum hawaiiense* that were burned were destroyed by the fire, and no signs of resprouting were observed up to one year following the fire. Only germinating seeds of *T. arenarium* have been seen in the field, while regeneration of the other taxa by seed has not been observed. The rare subshrubs or viney species, however, were not killed by the wildfire. *Haplostachys haplostachya, Silene hawaiiensis,* and *Stenogyne angustifolia* all resprouted within in one month of the fire. Also, *Haplostachys* and *S. angustifolia* both were regenerating from seed after sufficient precipitation fell following the fire. Browsing of

regrowth by feral animals following the fire appeared to have a much more negative impact on the overall health of the plants than did the wildfire alone. The fire would probably not have any direct impacts on these subshrubby species.

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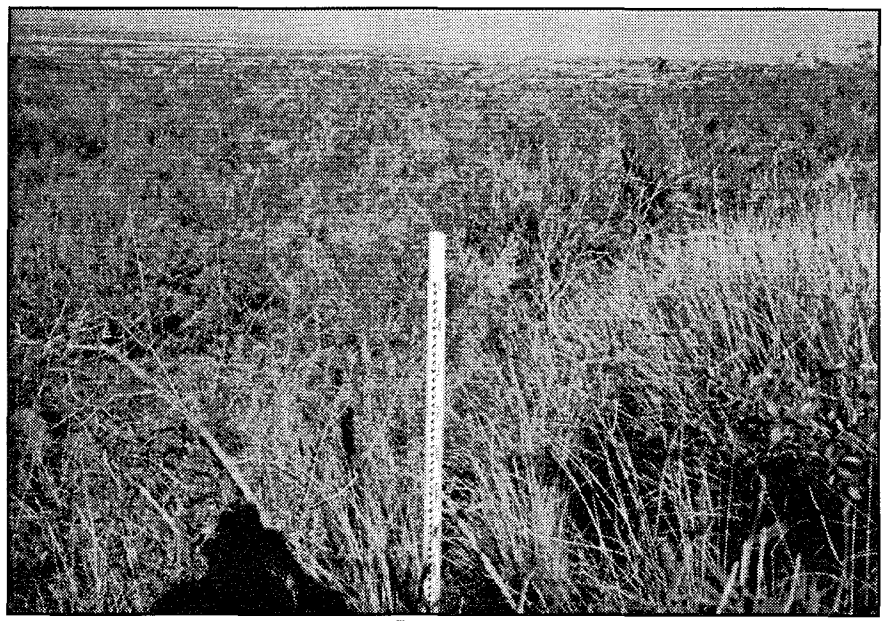
APPENDIX FIGURES



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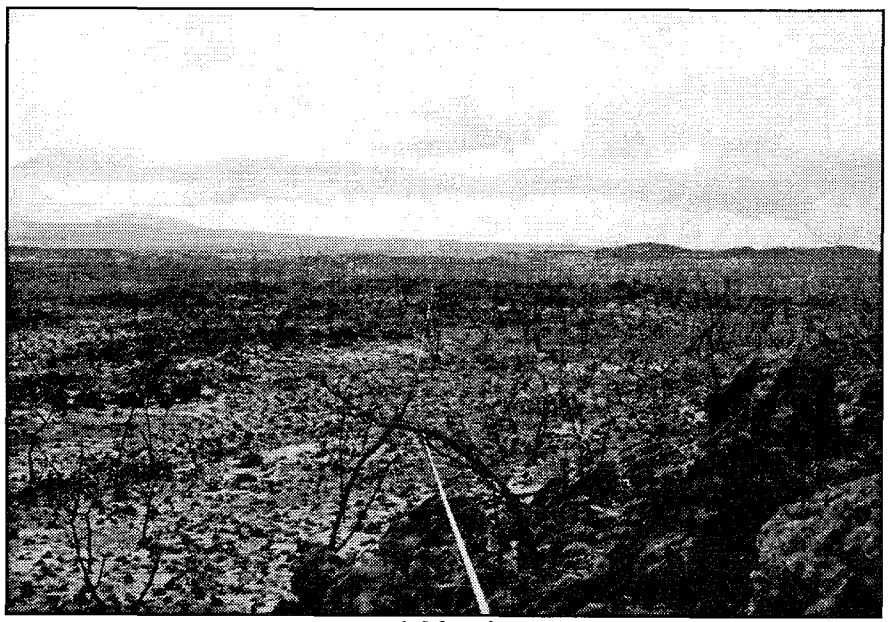

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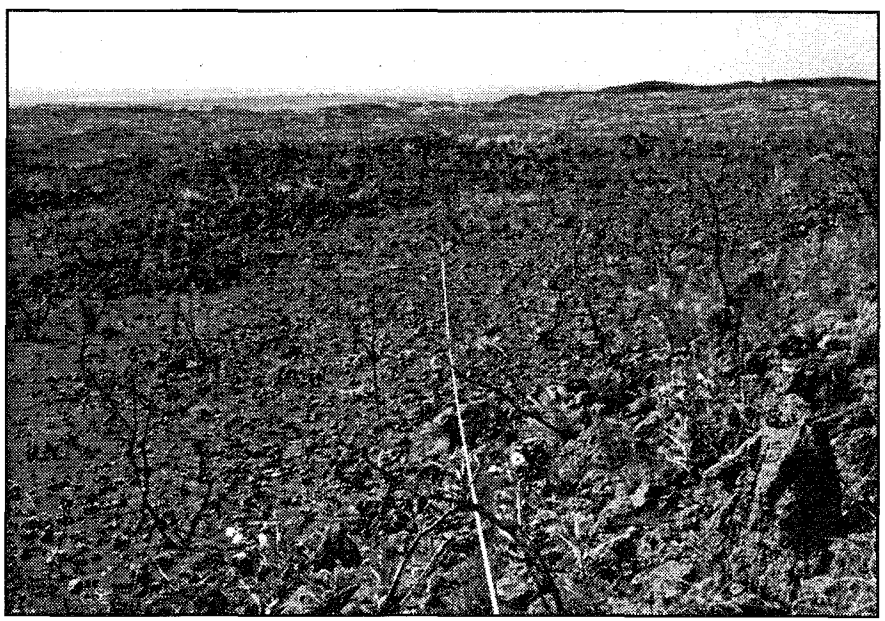
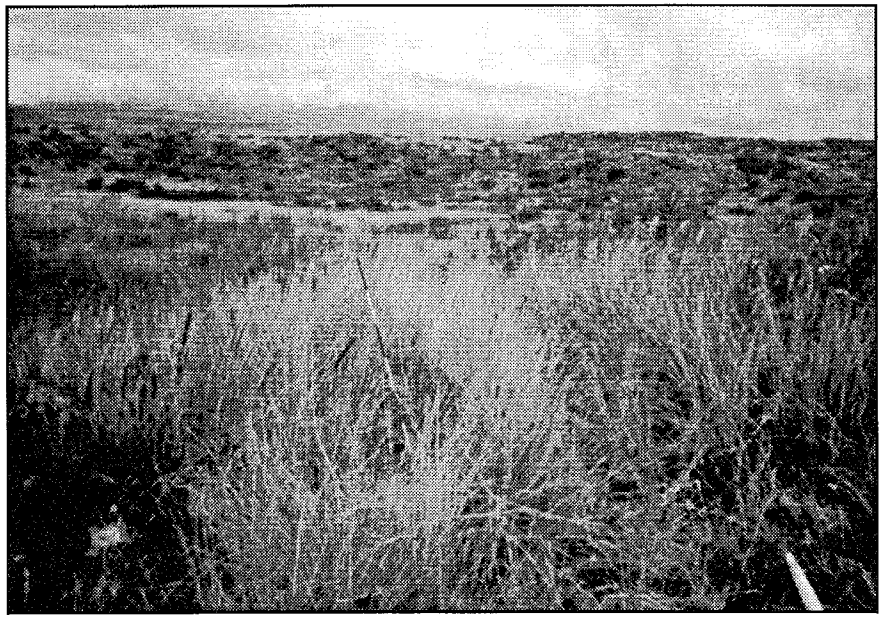


6 Months

1 Year

Appendix Figure 1. Photographic record (Plot 35) documenting the visual impacts of wildfire on vegetation in the Kipuka Kalawamauna Endangered Plants Habitat, Pohakuloa Training Area, Hawaii, Hawaii.



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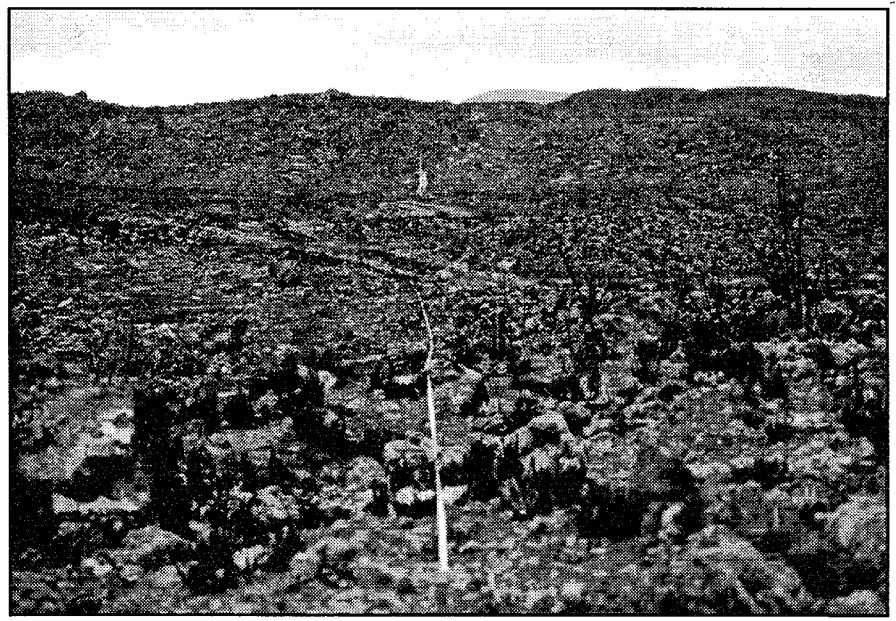

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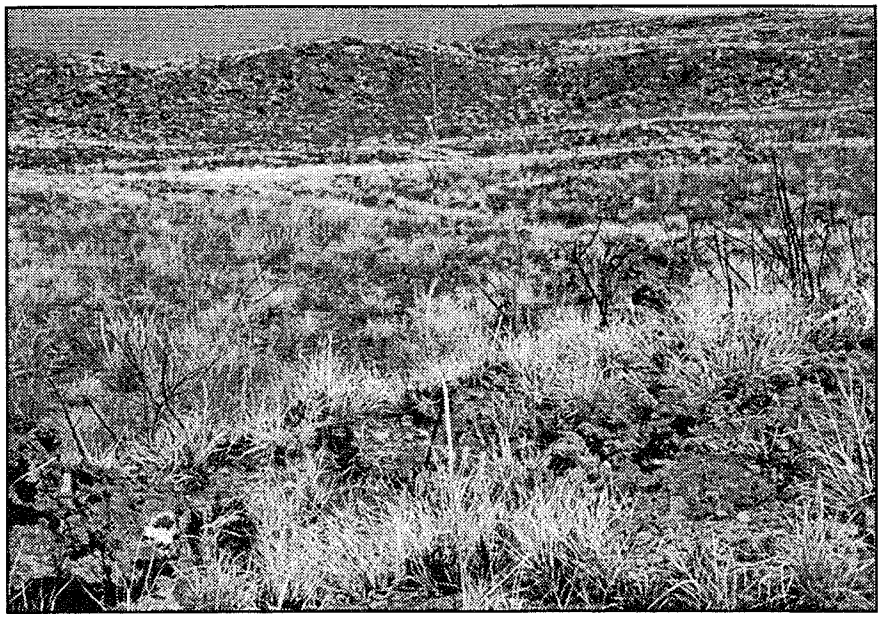
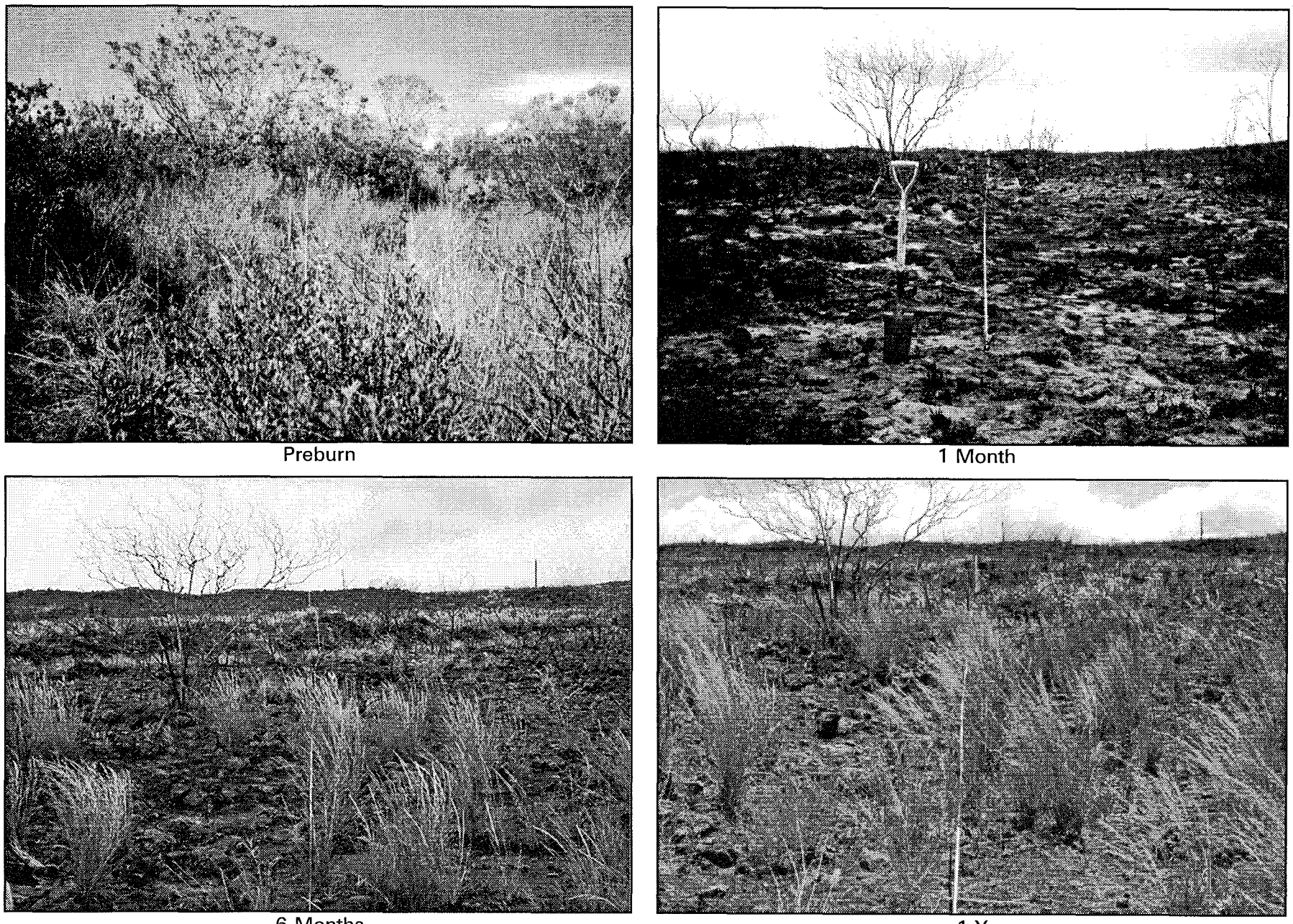


6 Months

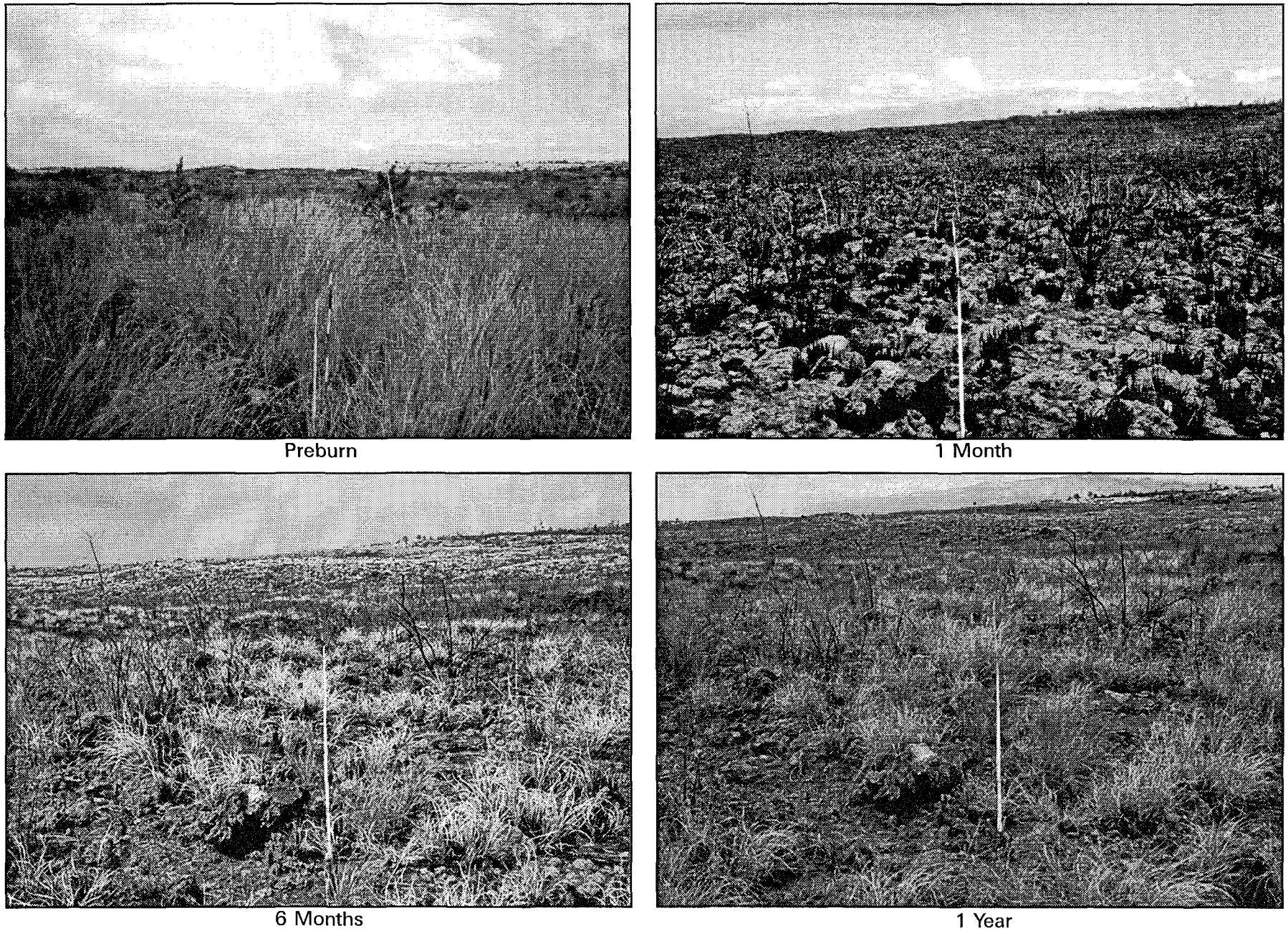
1 Year

Appendix Figure 2. Photographic record (Plot 36) documenting the visual impacts of wildfire on vegetation in the Kipuka Kalawamauna Endangered Plants Habitat, Pohakuloa Training Area, Hawaii, Hawaii.

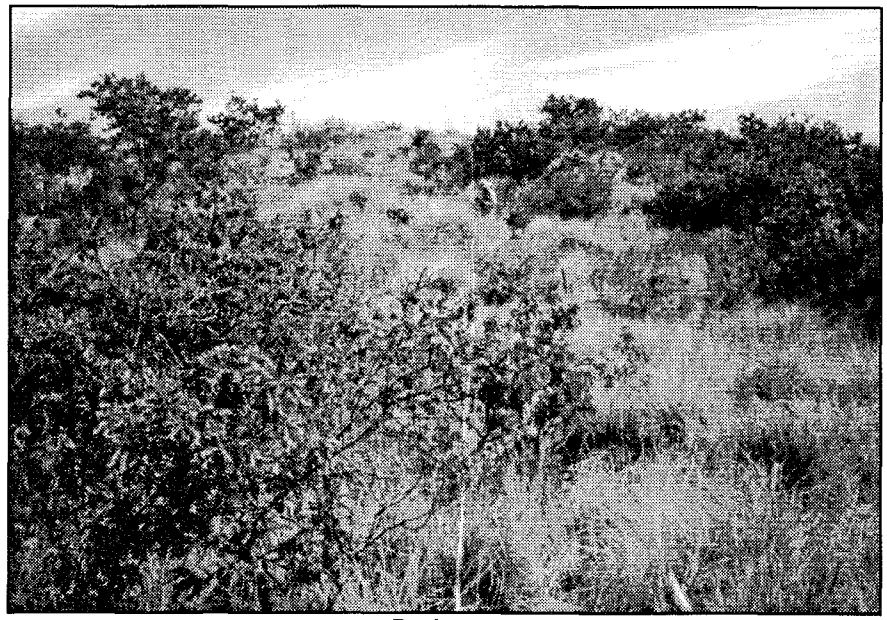


Appendix Figure 3. Photographic record (Plot 37) documenting the visual impacts of wildfire on vegetation in the Kipuka Kalawamauna Endangered Plants Habitat, Pohakuloa Training Area, Hawaii, Hawaii.

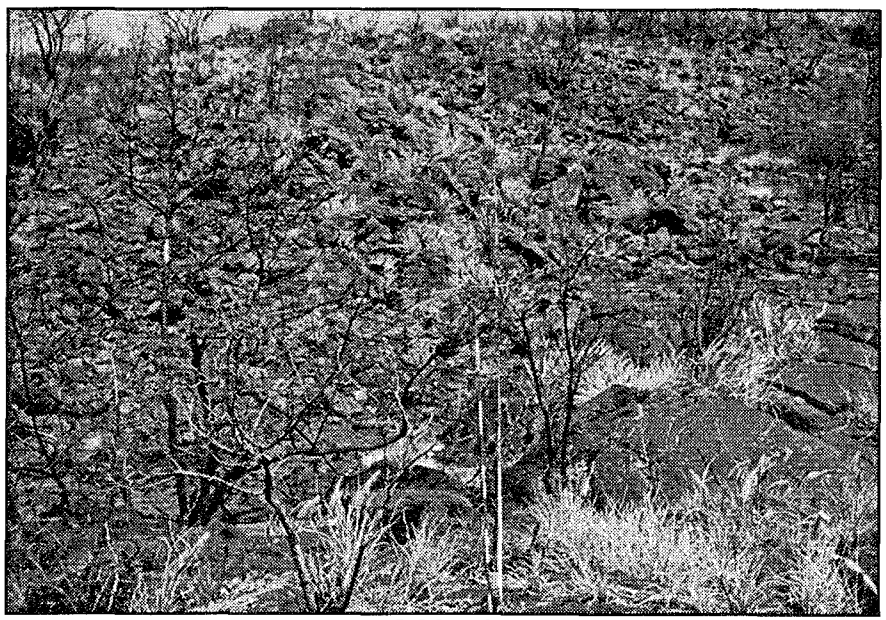
Appendix Figure 4. Photographic record (Plot 38) documenting the visual impacts of wildfire on vegetation in the Kipuka Kalawamauna Endangered Plants Habitat, Pohakuloa Training Area, Hawaii, Hawaii.

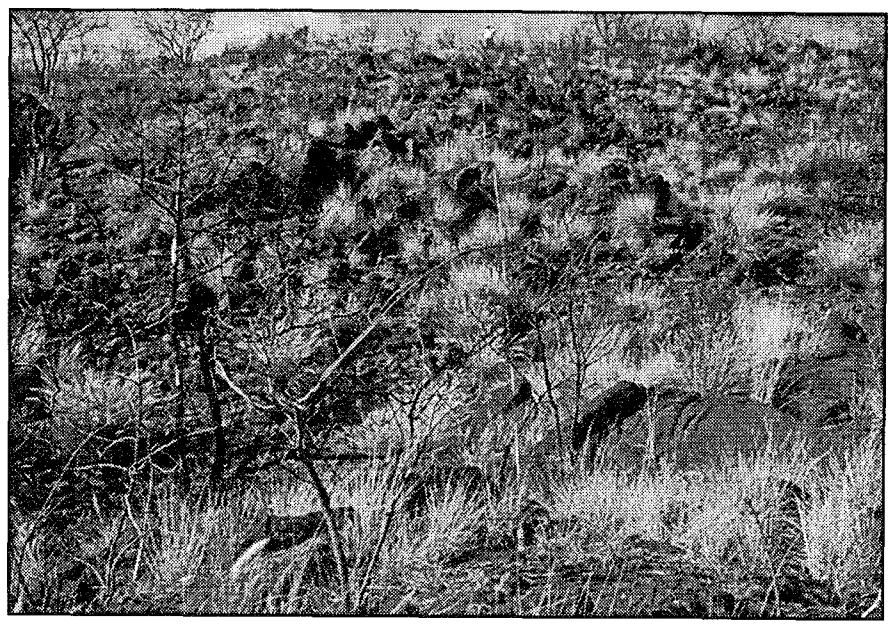


Appendix Figure 5. Photographic record (Plot 39) documenting the visual impacts of wildfire on vegetation in the Kipuka Kalawamauna Endangered Plants Habitat, Pohakuloa Training Area, Hawaii, Hawaii.

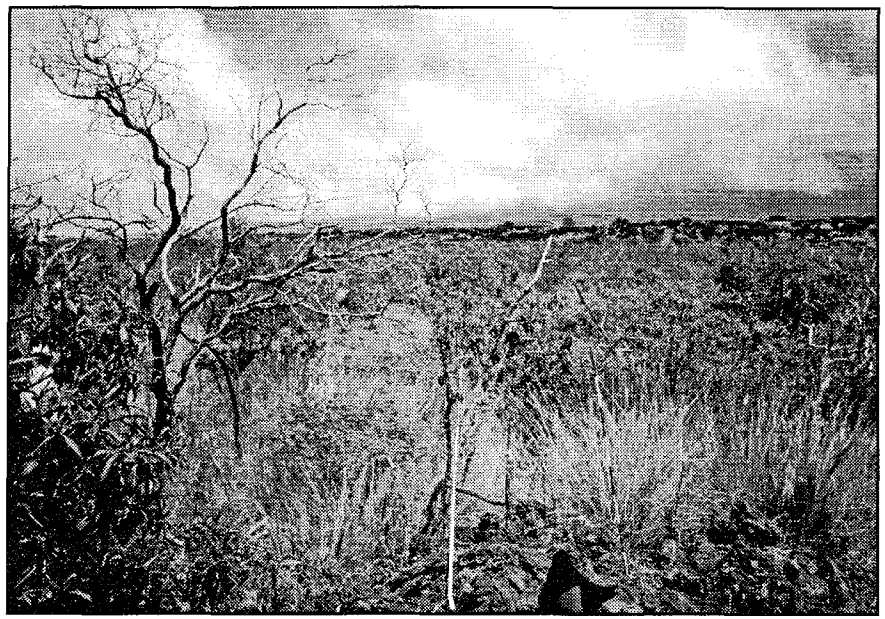

Preburn


1 Month


6 Months


1 Year

Appendix Figure 6. Photographic record (Plot 49) documenting the visual impacts of wildfire on vegetation in the Kipuka Kalawamauna Endangered Plants Habitat, Pohakuloa Training Area, Hawaii, Hawaii.



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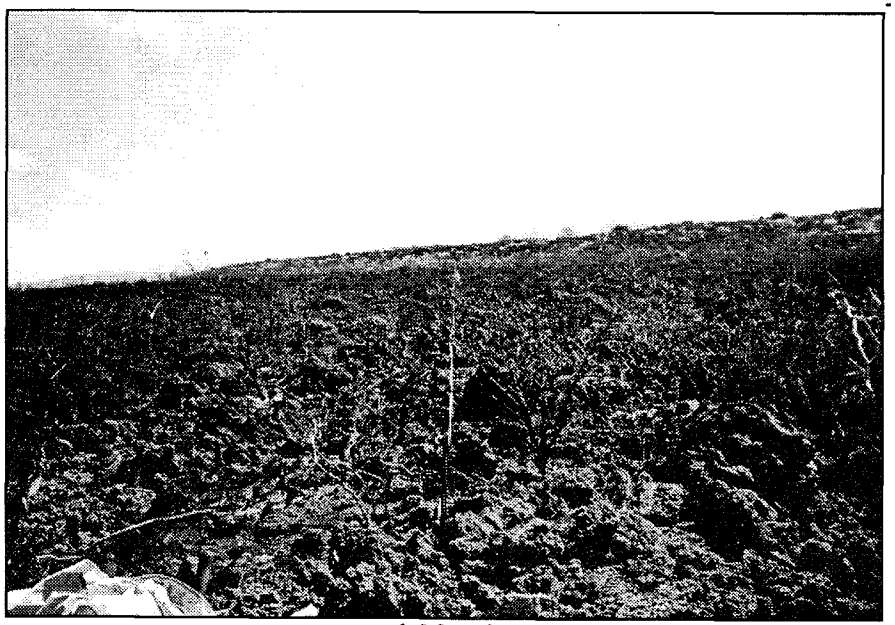

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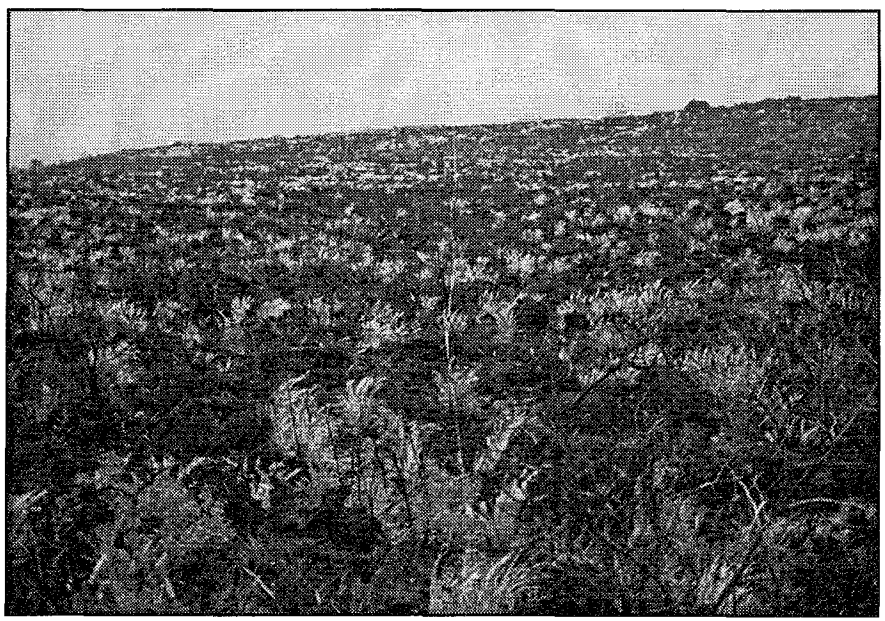
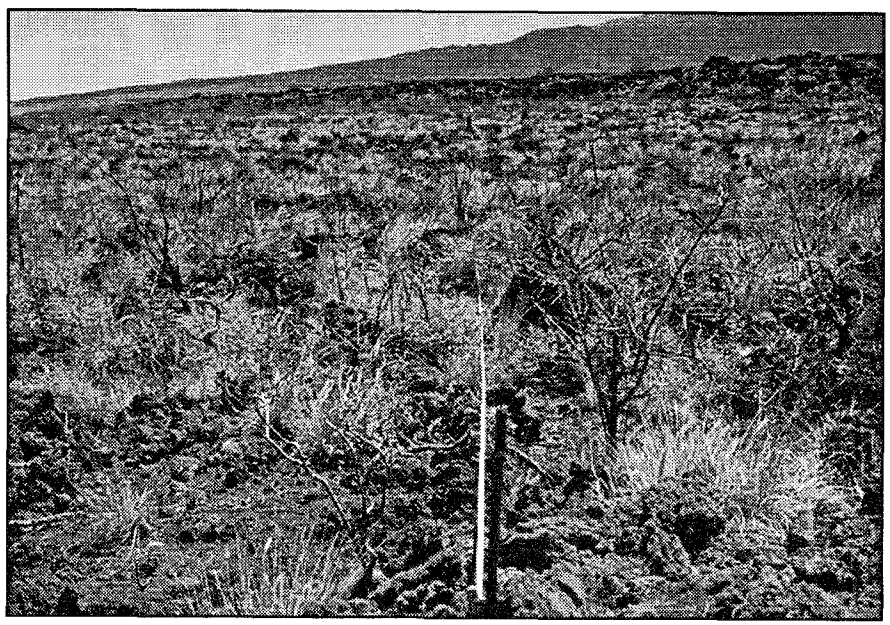
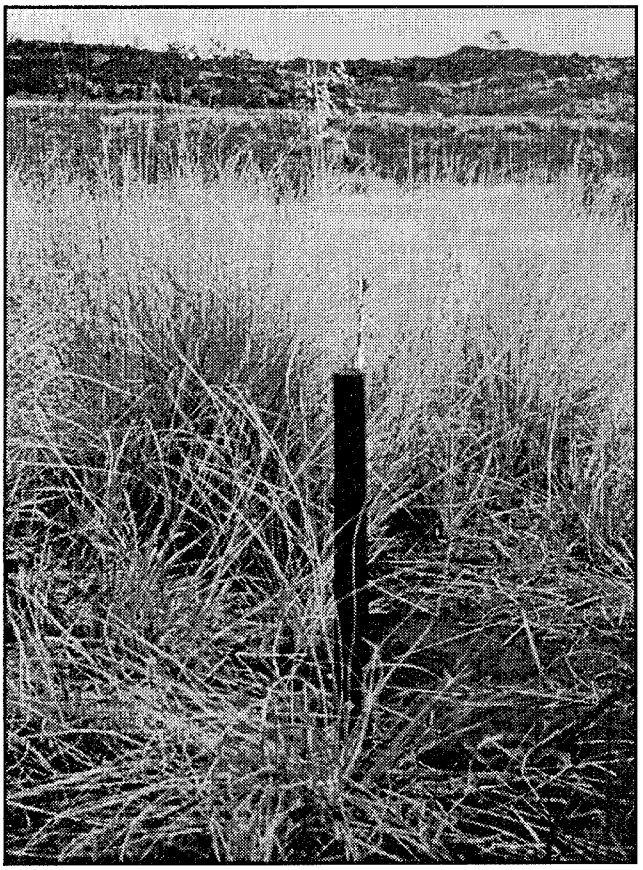


6 Months



1 Year

Appendix Figure 7. Photographic record (Plot 101) documenting the visual impacts of wildfire on vegetation in the Kipuka Kalawamauna Endangered Plants Habitat, Pohakuloa Training Area, Hawaii, Hawaii.



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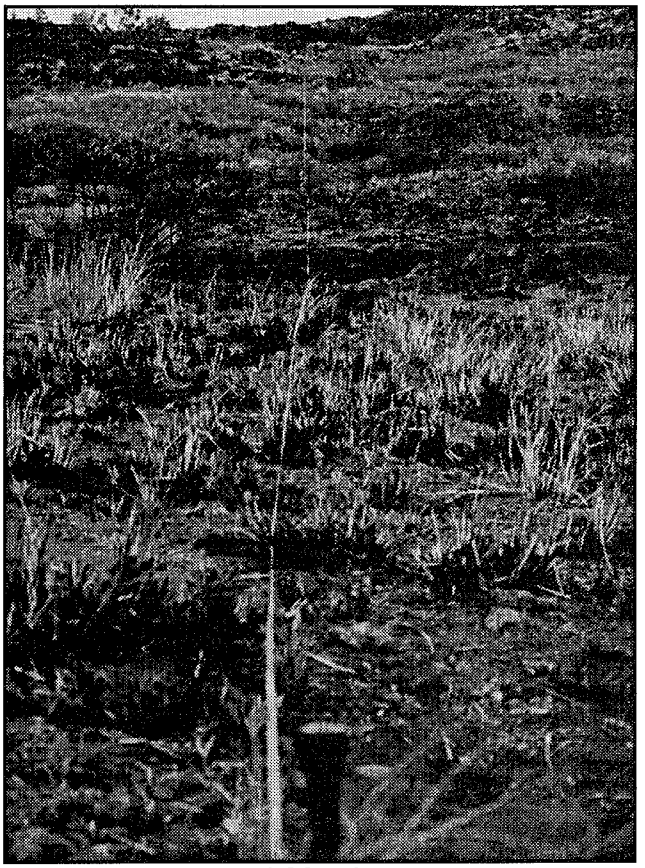
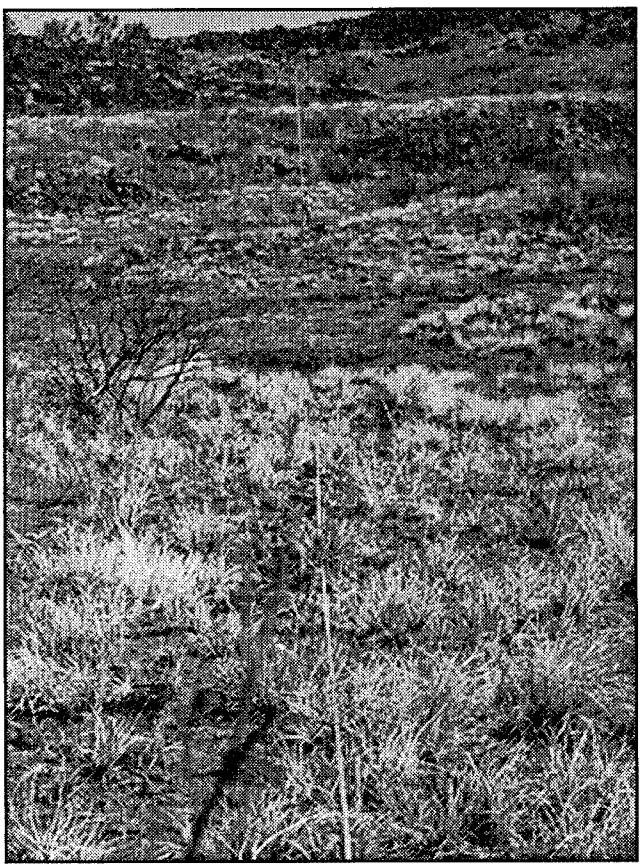
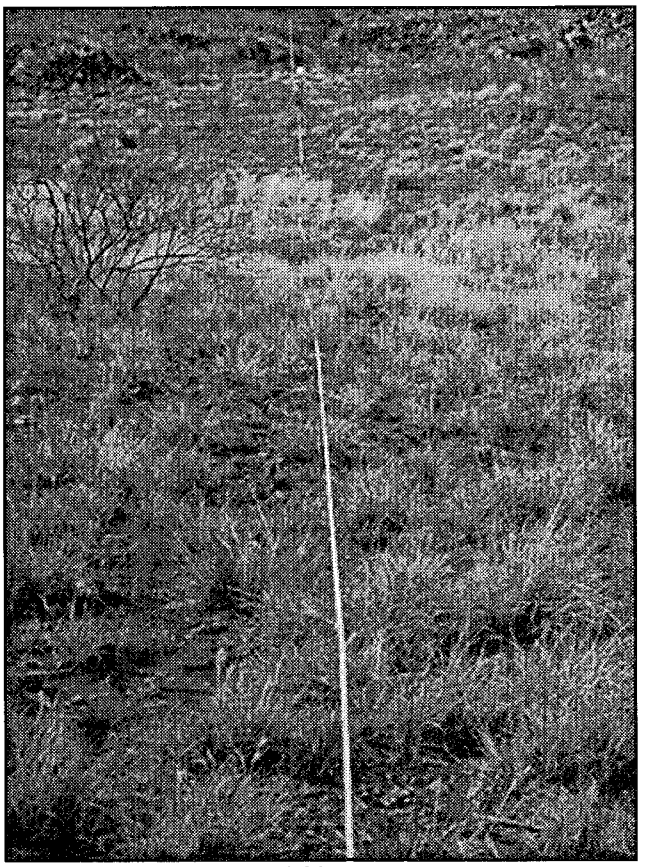


1 Month

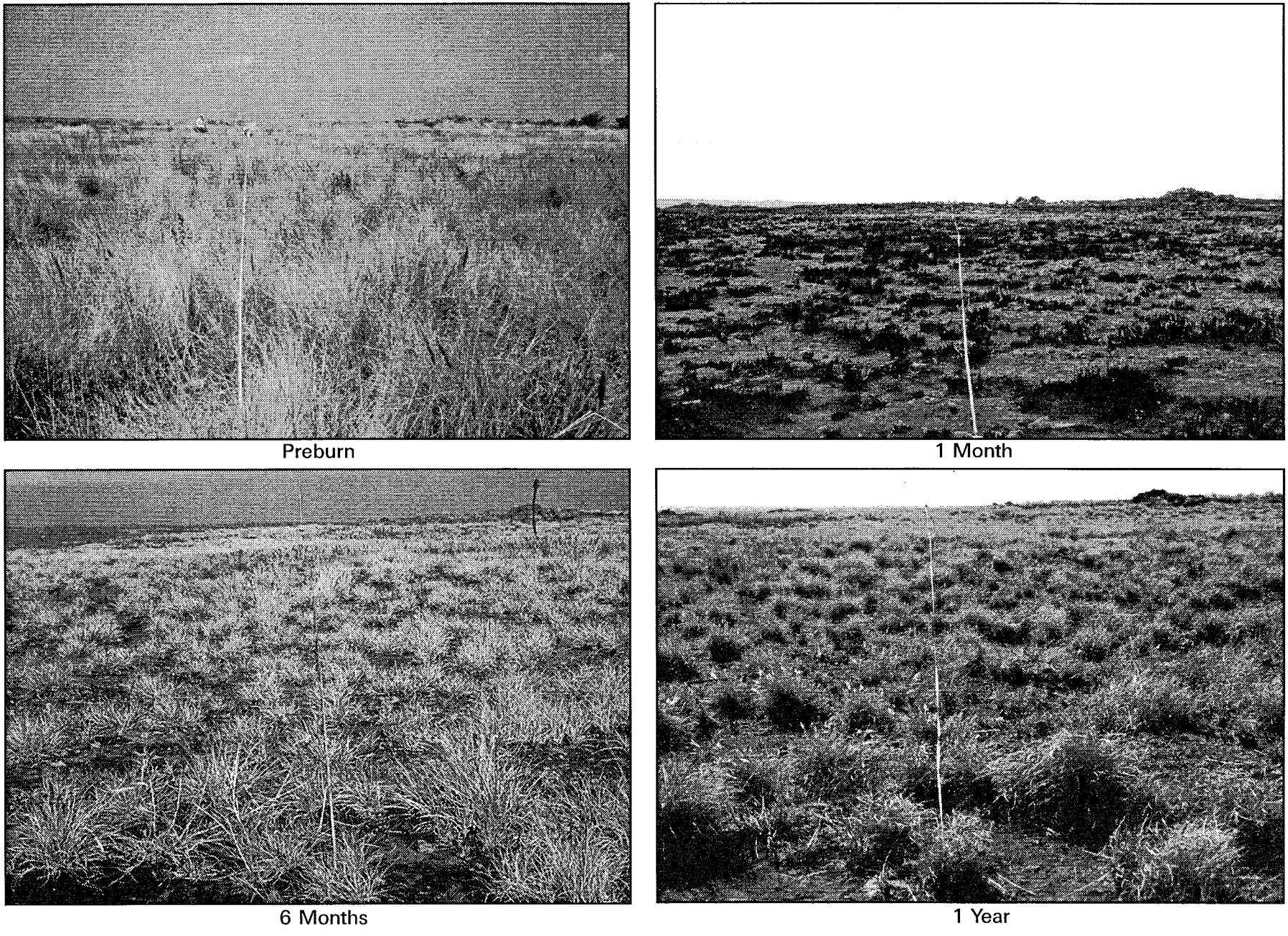


6 Months

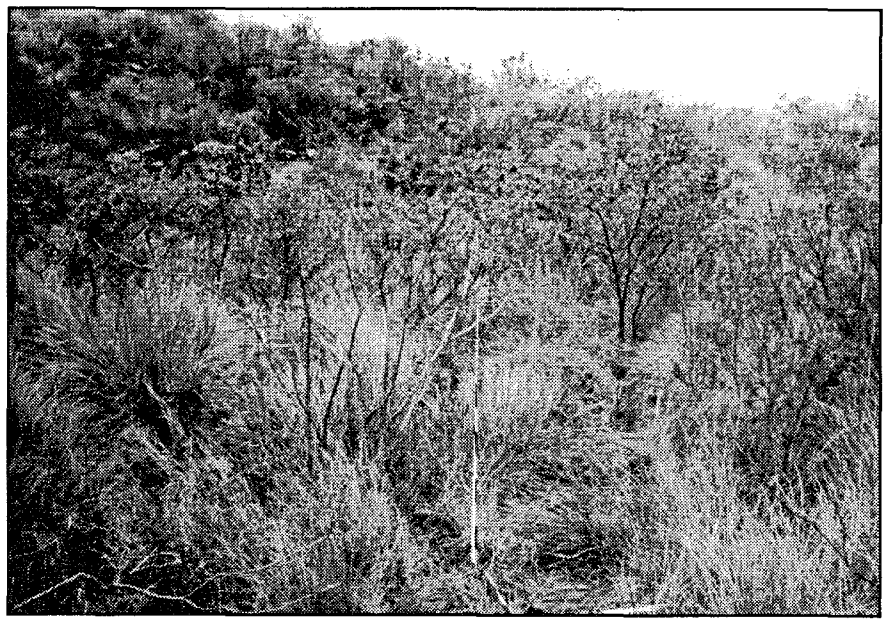


1 Year

Appendix Figure 8. Photographic record (Plot 142) documenting the visual impacts of wildfire on vegetation in the Kipuka Kalawamauna Endangered Plants Habitat, Pohakuloa Training Area, Hawaii, Hawaii.



Appendix Figure 9. Photographic record (Plot 143) documenting the visual impacts of wildfire on vegetation in the Kipuka Kalawamauna Endangered Plants Habitat, Pohakuloa Training Area, Hawaii, Hawaii.



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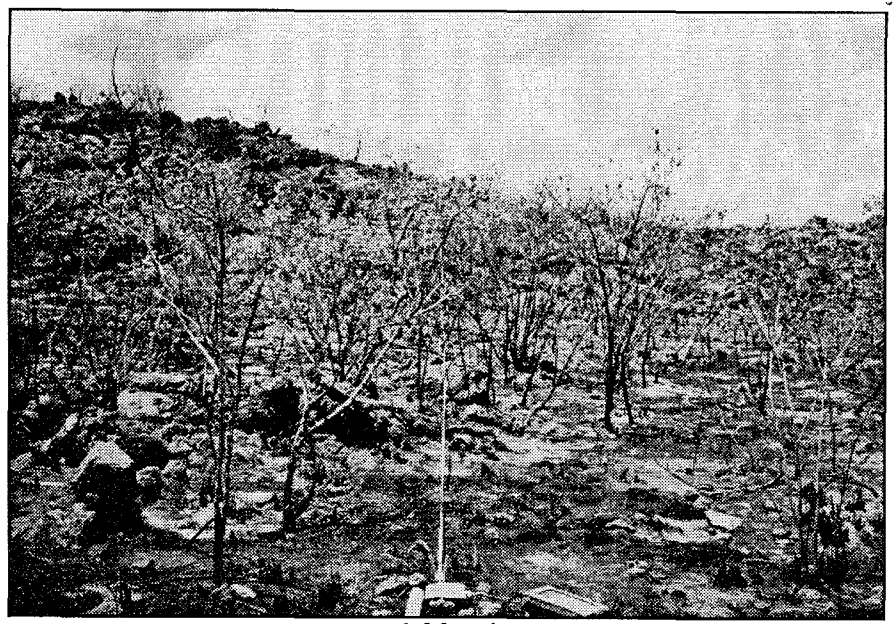
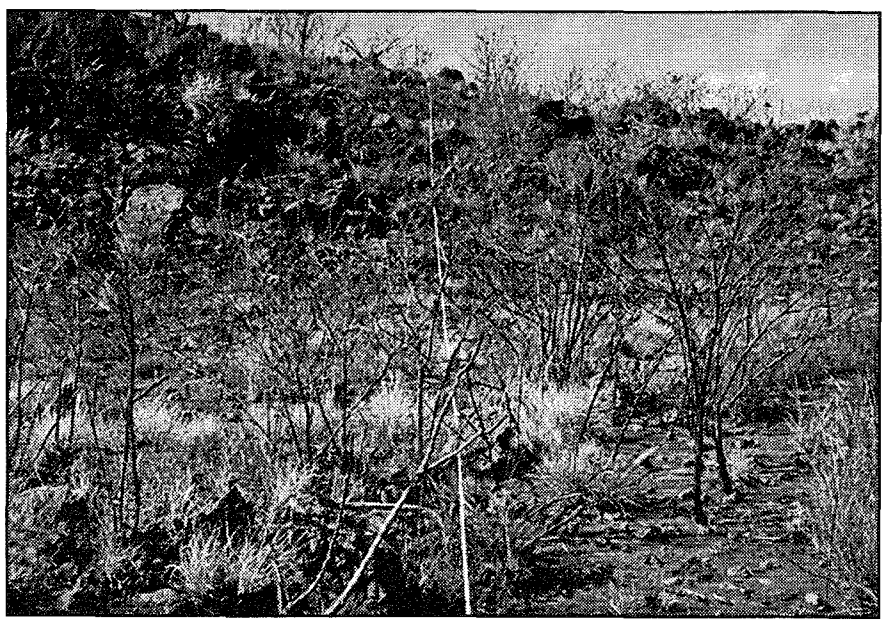
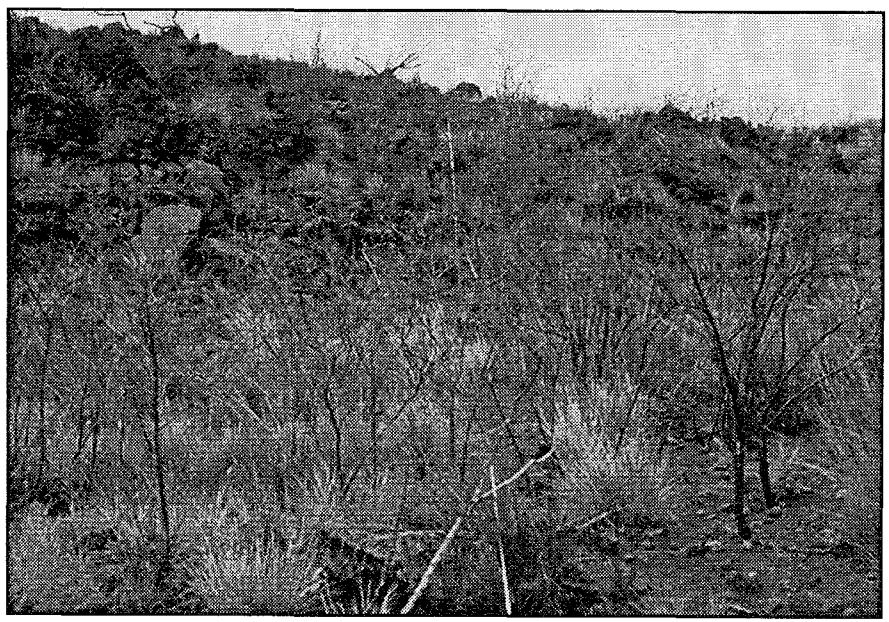


1 Month

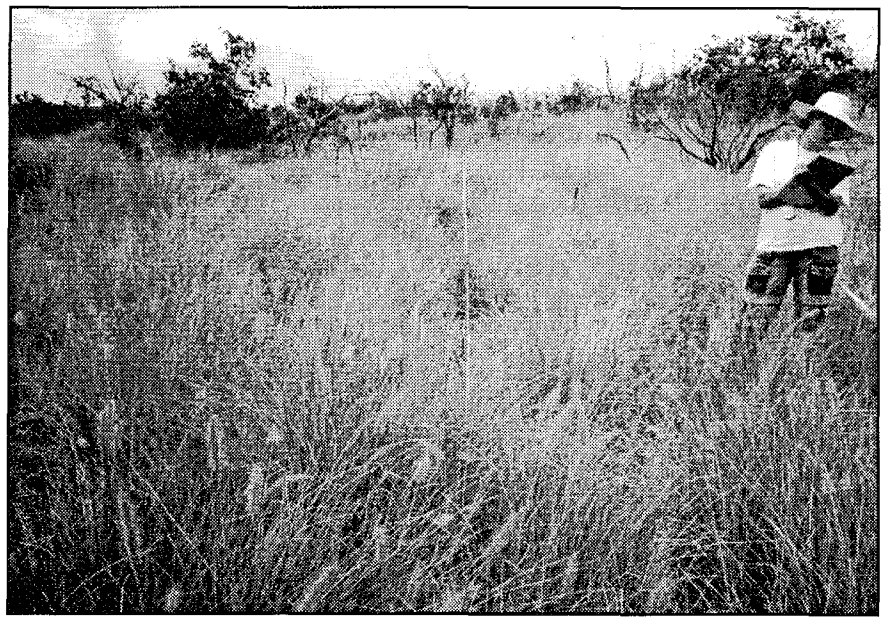


6 Months



1 Year

Appendix Figure 10. Photographic record (Plot 318) documenting the visual impacts of wildfire on vegetation in the Kipuka Kalawamauna Endangered Plants Habitat, Pohakuloa Training Area, Hawaii, Hawaii.



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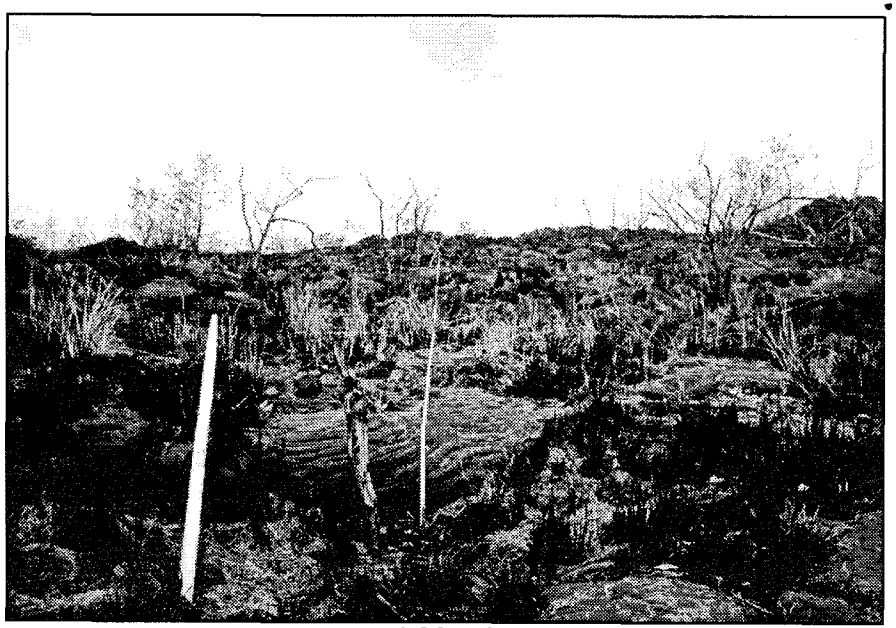
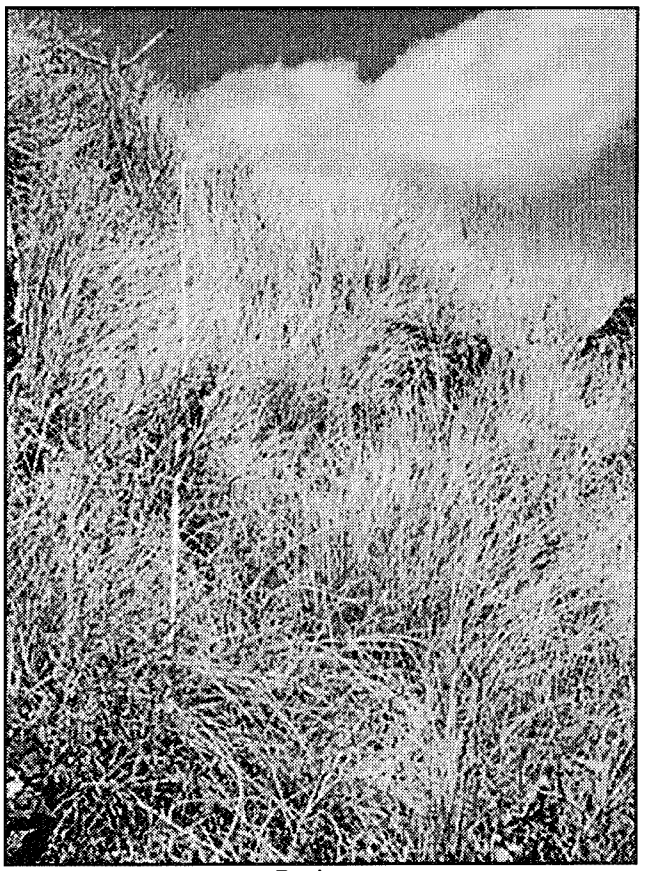


1 Month

6 Months

1 Year

Appendix Figure 11. Photographic record (Plot 319) documenting the visual impacts of wildfire on vegetation in the Kipuka Kalawamauna Endangered Plants Habitat, Pohakuloa Training Area, Hawaii, Hawaii.

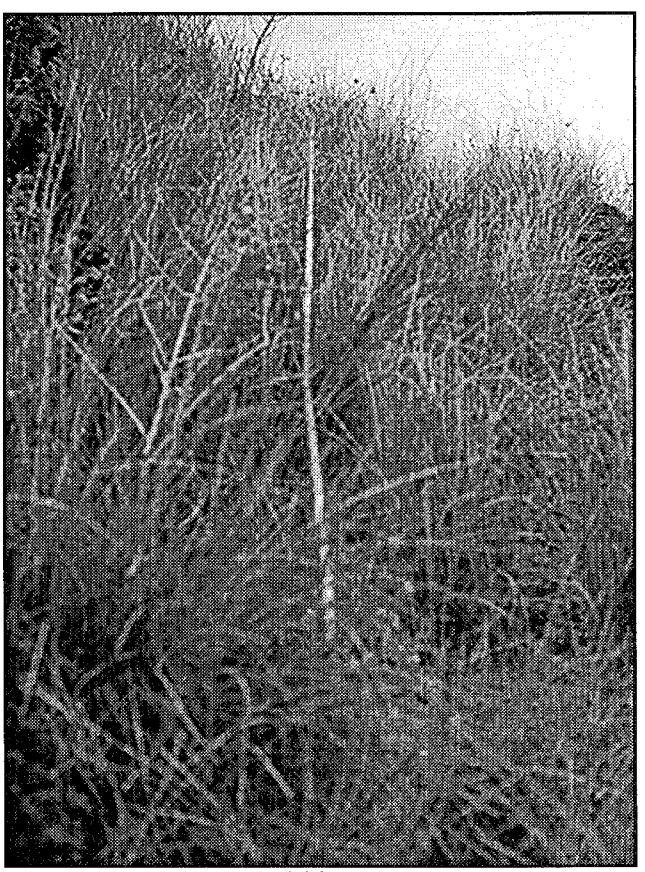


Preburn

MISSING

1 Month

6 Months

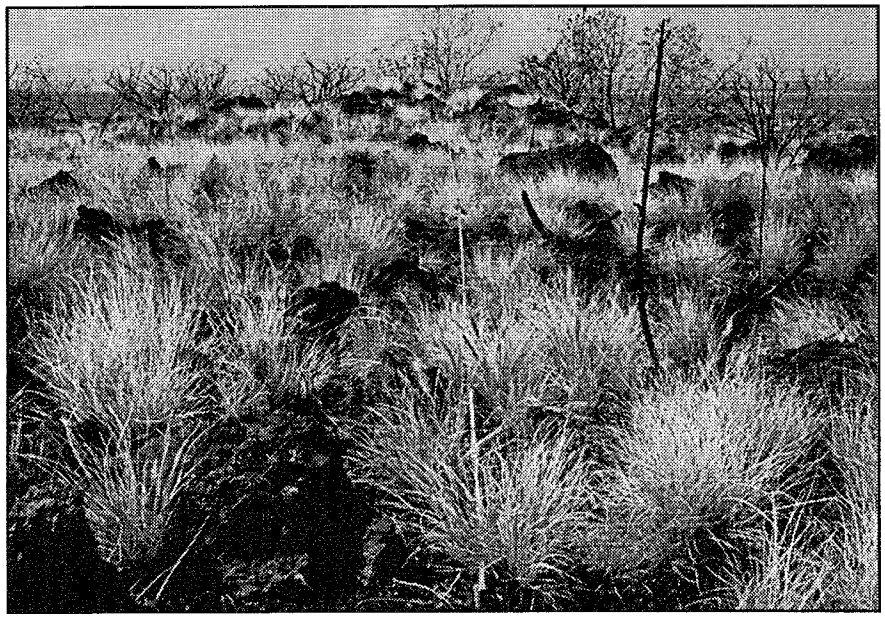


1 Year

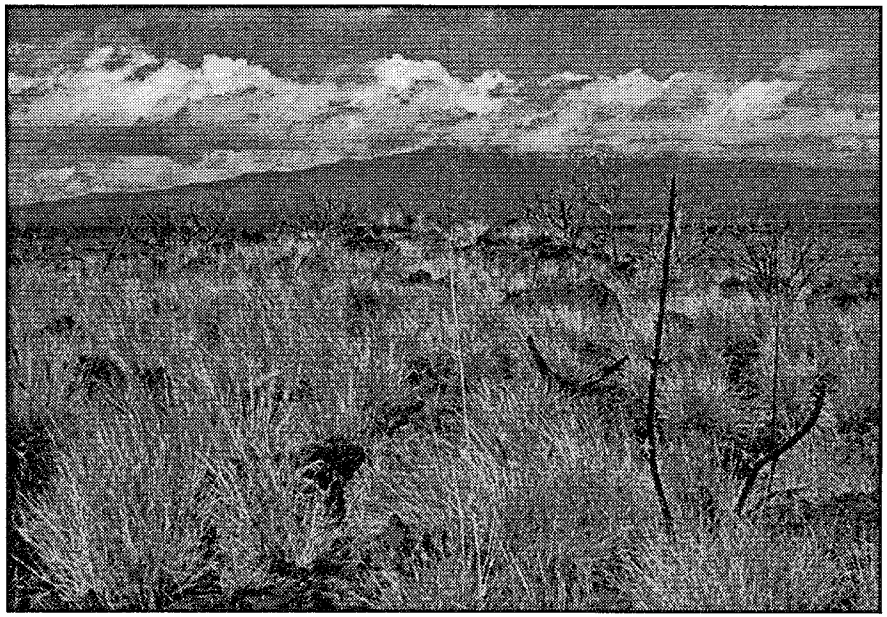
Appendix Figure 12. Photographic record (Plot 329) documenting the visual impacts of wildfire on vegetation in the Kipuka Kalawamauna Endangered Plants Habitat, Pohakuloa Training Area, Hawaii, Hawaii.

Preburn

1 Month

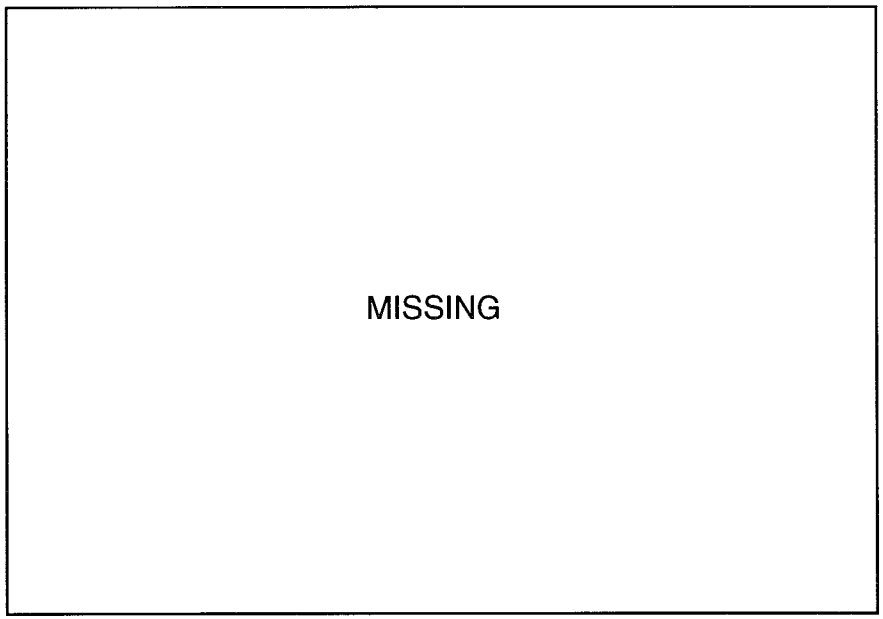


6 Months

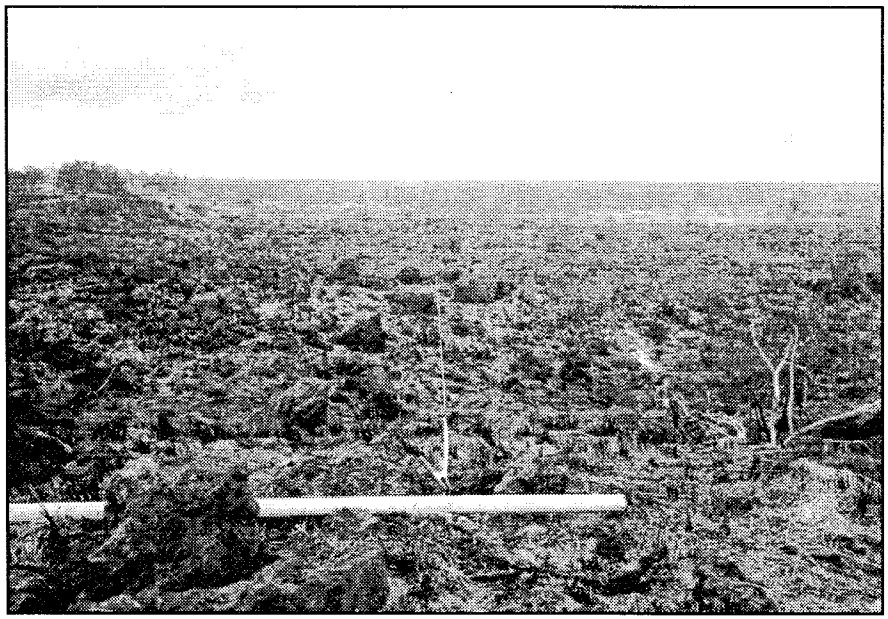


1 Year

Appendix Figure 13. Photographic record (Plot 335) documenting the visual impacts of wildfire on vegetation in the Kipuka Kalawamauna Endangered Plants Habitat, Pohakuloa Training Area, Hawaii, Hawaii.



Preburn



1 Month

6 Months

1 Year

Appendix Figure 14. Photographic record (Plot 337) documenting the visual impacts of wildfire on vegetation in the Kipuka Kalawamauna Endangered Plants Habitat, Pohakuloa Training Area, Hawaii, Hawaii.

DEPARTMENT OF THE ARMY
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504 SCOTT STREET
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REPLY TO
ATTENTION OF:

MCMR-RMI-S (70-1y) 21 Apr 97

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1. The U.S. Army Medical Research and Materiel Command has reexamined the need for the limitation assigned to technical reports written for Grant Number DAMD17-94-V-4038. Request the limited distribution statement for Accession Document Number ADB206385 be changed to "Approved for public release; distribution unlimited." This report should be released to the National Technical Information Service.

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FOR THE COMMANDER:

for GARY R. GILBERT
Colonel, MS
Deputy Chief of Staff for
Information Management

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