THE EFFECTS OF FIRE UPON A HAWAIIAN MONTANE ECOSYSTEM

Terry T. Parman
Hawaii Volcanoes National Park
Hawaii 96718

In the early afternoon of August 13, 1975, a small fire was reported by Park Service personnel along the eastern boundary of Hawaii Volcanoes National Park at an elevation of 4900 feet. Pushed by strong easterly trade winds, the fire spread rapidly westward from the Ke-au-hou Ranch boundary, across the Mauna Loa Scenic Road and into the seasonally dry mountain-parkland and savannah grassland segments of Hawaii Volcanoes National Park. During the next four days this fire consumed some 1800 acres of grassland, native shrubland, and *Acacia koa* colonies, before being contained on the Ka-pāpala section of Parker Ranch, 4.8 miles southwest of its origin.

Vegetation within the burned area can be roughly divided into three community types: 1) closed canopy *Acacia koa* colonies with a mixed grass understory, 2) open native shrubland with native and introduced grasses, 3) mixed *Acacia koa*, *Sophora chrysophylla* forest with mixed grass and shrub understory.

Ten study transects were established in the burn area three weeks after the fire, in order to monitor recovery of vegetation. Three of the study plots are located inside colony stands of *Acacia koa*. One study site is situated inside a mixed forest kīpuka consisting of *Sophora chrysophylla*, *Acacia koa* and a few small *Metrosideros* sp. The other six transects are located in native shrub and mixed grassland communities. All ten transects are situated at elevations between 4400 feet and 5100 feet.

Percent ground cover by species for each transect was determined by the point frequency method. Point sampling was done using finely sharpened bronze rods mounted in a one-meter long wooden frame. Five points per meter, at 20 cm intervals, were sampled in each of the ten sixty-meter transects, resulting in 300 points per transect. Sampling along each transect was repeated every two months from September 1975 through early August 1976.

I would like to briefly discuss the recovery patterns which have occurred during the first twelve months following the fire.

Grass-Shrubland Communities

Six sixty-meter line transects were established in six separate grass-shrub locations within the burn area. Within these six sites there are eight commonly occurring grasses: three native species, *Deschampsia australis*, *Eragrostis atropioides*, *Eragrostis variabilis*; and five exotic species, *Microlaena stipoides*, *Paspalum dilatatum*, *Holcus lanatus*, *Sporobolus africanus*, and *Anthoxanthum odoratum*. The most common shrub species occurring within these transects are *Dodonaea sandwicensis* and *Styphelia tameiameiae*. The introduced shrub Jerusalem cherry, *Solanum pseudocapsicum*, is also a prominent member of many of the communities affected by the fire.

In all six of the shrub-grassland plots, ground cover was reduced to less than five percent immediately following the fire. The only vegetation left standing after the fire were the charred remains of *Styphelia* and *Dodonaea*.

Changes after six months. During the first six-month period following the fire, two of the predominant inhabitants of the grass-shrub communities were exotic herbaceous species, *Hypochaeris radicata* and *Plantago lanceolata*; these plus six other herbaceous species accounted for 27.5 percent of the total ground cover after six months. The dominant component of these communities was the small fern *Pteridium aquilinum* var. *decompositum* which accounted for 7.5 percent of the total cover. Grass species, both native and exotic, did not begin to reappear until early January 1976, and by March 1976 only eight species had become established within the six grass-shrubland transects. After six months, three endemic grasses, *Deschampsia* and the two *Eragrostis* species, accounted for 4.2 percent of the total ground cover. The five species of exotic grasses accounted for 8.5 percent of the cover. Of the three endemic grass species *Eragrostis* appeared to respond most favorably during the first six months. By March *Eragrostis* accounted for 81 percent of the endemic grasses in the shrub-grassland plots. By far the most successful grass to reestablish itself within the first six months in the grass-shrub plots was *Paspalum dilatatum*. By March 1976 it accounted for 5.6 percent of the total ground cover and 45 percent of the grass cover in the six grass-shrubland communities. *Holcus lanatus*, one of the most common exotic grass species in the savannah-grassland and mountain parkland regions, showed only marginal success in reestablishing itself soon after the fire. Six months after the fire *Holcus* occupied only 1.5 percent of the total cover in the grass-shrubland communities.

One of the most discouraging results of the six-month vegetation tally was the lack of regeneration among native shrub species. During the March sampling very little

evidence of regeneration of native shrubs could be detected. *Dodonaea* sp. seedlings were found scattered very sparsely on only three of the six grass-shrub transects. Not a single live specimen of *Styphelia* sp. was observed on any of the grass-shrubland transects during the March sampling. Six months after the fire 47 percent of the grass-shrubland transects were devoid of vegetative cover while litter occupied 16 percent of the ground in the grass-shrubland communities.

Changes after one year. Cover percentage for all dominant species, both grasses and shrubs, showed no major change at the end of one year's sampling, although small increases in cover percentages were noted for each of the eight previously occurring grasses. *Paspalum dilatatum* exhibited the greatest increase in cover. *Paspalum* accounted for 11.2 percent of the total cover, followed by *Holcus lanatus* (5.1 percent), at the end of one year's sampling. The two species of native *Eragrostis* increased in cover from 0.8 percent in March to 1.8 percent in August 1976.

A slight competitive advantage was seen in the exotic grasses, which at the end of one year's sampling accounted for 67% of the grass cover in the shrub-grassland plots, while the endemic grasses showed a 4 percent decline accounting for 32 percent of all grass cover in August 1976 as compared to 36 percent in March.

A slight increase in plant litter, some 11 percent, from 6 to 17 percent, partially explains a reduction in the amount of barren soil seen in the grass-shrubland plots at the end of one year, from 47 percent in March to 36 percent in August 1976.

Conspicuously absent at the end of one year's sampling again are the native shrub species. *Dodonaea* sp., although visibly present on all six of the shrubland plots, accounted for less than 0.5 percent of the total plant cover. Newly emergent sprouts of *Styphelia* sp., the other dominant shrub in these communities, were observed on only one transect during the August 1976 sampling.

Understory Regeneration in *Acacia koa* Communities

A somewhat different pattern of understory regeneration is seen within the *Acacia koa* colonies. The increased shading of the understory by the remains of the *Acacia* canopy accounts in part for the differences in species composition that can be observed within the koa plots, as compared to the grass-shrubland communities.

Three exotic grass species, *Anthoxanthum odoratum*, *Holcus lanatus*, and *Paspalum dilatatum* have established themselves as the dominant understory components within the koa communities.

Six months after the fire, these three species accounted for 21 percent of the total ground cover. The single most abundant species after six months, however, was *Pteridium aquilinum* which occupied almost 11 percent of the total cover. The three native grasses occurring in these plots, *Deschampsia australis* and the two *Eragrostis* species, did not appear to do as well in the partially shaded koa plots as they did in the full sunlight of the grass-shrubland communities. These three species accounted for only 0.5 percent of the total cover in the koa communities as compared to 36 percent in the grass-shrubland plots after six months. Barren ground and plant litter together occupied 53 percent of the surface area within the koa plots, with cover values of 25 and 28 percent respectively.

Species composition in the koa understory revealed few changes after the second six-month sampling period, with only two new plant species occurring within the koa stands. One of the two newly emergent species, *Eragrostis grandis*, an endemic grass, was observed along two of the *Acacia koa* transects during June, and by August 1976 *Eragrostis* accounted for slightly over one percent of the total cover inside the koa plots. *Rubus penetrans* accounted for 5.5 percent of the plant cover inside the koa plots during the August 1976 sampling. Growth of this noxious exotic will be monitored carefully in the coming months with hopes that its spread will be contained by natural successional trends.

Two of the exotic grasses occurring within the koa communities, *Holcus lanatus* and *Paspalum dilatatum*, both showed moderate increases in cover percentages after one year's sampling, with *Paspalum* becoming the dominant understory component inside the koa colonies. Together these two species comprised 32 percent of the total ground cover in the koa communities, one year after the fire, with *Paspalum* alone accounting for 19 percent of the ground cover.

Acacia koa Regeneration

Regeneration of *Acacia koa* was first noted in early November 1975 on transect #4 at 4700 feet. Several small, newly emergent root sprouts were observed on the outer edge of the transect. Abundant regeneration of *Acacia koa* in the other two *Acacia* study plots was not observed until late December 1975. Koa regeneration within the study plots was noted to be occurring almost exclusively by root sprouting. Fewer than 20 *Acacia koa* seedlings were tallied in the plots during the first twelve months of recovery following the fire.

Newly emergent koa root sprouts accounted for only 0.5 percent of the ground cover six months after the fire, but encouragingly, koa sprouts increased their cover value

by some 5.5 percent in the second six-month period, occupying 6.2 percent of the sampled area at the end of one year.

Preliminary results of this study indicate that *Acacia koa* responds quite favorably to disturbance by grass and brush fires. Fires of moderate intensity, such as this one, do not appear to severely damage the root systems of *Acacia koa*, although most of the trees suffered extensive damage to the trunk and crown portions. While cover values for koa do not indicate it, sizeable increases in area for each of the colony stands have been noted. Much of the understory was removed in the areas adjacent to colony stands of koa, which has allowed numerous new root sprouts to emerge outside the previous perimeter of the old colonies. With little initial competition from surrounding vegetation, these new root sprouts appear to be successful in extending the area of the colony stands.

Summary

After one year's sampling of the three communities affected by the August 1975 fire, it appears that a large majority of the floral components of the mountain parkland-savannah grassland ecosystems are favorably adapted to disturbance by fire.

Species composition within these two ecosystems does not appear to have been appreciably altered by the fire, although the native shrubs in these ecosystems are responding at a much slower rate than the therophytes or other phanerophytes in this region. This slow regeneration response by the native shrubs is not altogether unexpected as regeneration of these species occurs almost exclusively by seed propagation. The moderately high heat created by the fire combined with the high heat-conducting capabilities of the fine ash soil destroyed virtually all of the viable seed from the shrubs within the burned area. It is anticipated that an increased rate of regeneration of native shrubs will be documented in the following year as new viable seed from unburned surrounding sources invades the burned area.

Appendix--Species List

Checklist of species by families. Citation names follow Fosberg (1966). X = exotic species, E = endemic species, and I = indigenous species.

COMPOSITAE	*Cirsium vulgare* (Savi) Tenore	X
	Conyza canadensis (L.) Cronq.	X
	Gnaphalium purpureum L.	X
	Hypochaeris radicata L.	X
	Sonchus oleraceus L.	X
	Senecio sylvaticus L.	X
CYPERACEAE	*Carex macloviana* D'Urv. var. *subfusca* (W. Boott) Kuek.	I
	Carex wahuensis C.A. Mey. var. *meyeri* Franch. & Savat.	E
DENNSTAEDTIACEAE	*Pteridium aquilinum* var. *decompositum* (Gaud.) Tryon	E
EPACRIDACEAE	*Styphelia tameiameiae* (Cham.) F. Muell.	E
	Vaccinium reticulatum Sm.	E
GENTIANACEAE	*Centarium umbellatum* Gilib.	X
GERANIACEAE	*Geranium carolinianum* var. *australe* (Benth.) Fosb.	X
GRAMINEAE	*Anthoxanthum odoratum* L.	X
	Andropogon virginicus L.	X
	Bromus rigidus Roth	X
	Bromus catharticus Vahl	X
	Cynodon dactylon (L.) Pers.	X
	Dactylis glomerata L.	X
	Deschampsia australis Nees ex Steud.	X
	Eragrostis atropioides Hbd.	E
	Eragrostis grandis Hbd. var. *grandis*	E

GRAMINEAE	*Eragrostis variabilis* (Gaud.) Hbd.	E
	Festuca megalura Nutt.	X
	Holcus lanatus L.	X
	Microlaena stipoides (Labill.) R. Br.	X
	Panicum tenuifolium H. & A.	E
	Paspalum dilatatum Poir.	X
	Sporobolus africanus (Poir.) Robyns & Tournay	X
IRIDACEAE	*Sisyrinchium acre* Mann	E
JUNCACEAE	*Juncus bufonius* L.	X
LEGUMINOSAE	*Acacia koa* var. *hawaiiensis* Rock	E
LYTHRACEAE	*Lythrum maritimum* HBK.	X
ONAGRACEAE	*Epilobium oligodontum* Haussk.	X
OXALIDACEAE	*Oxalis corniculata* L.	X
POLYGONACEAE	*Rumex acetosella* L.	X
PRIMULACEAE	*Anagallis arrensis* L.	X
SOLANACEAE	*Solanum nigrum* L.	X
SAPINDACEAE	*Dodonaea sandwicensis* Sherff	E
RUBIACEAE	*Coprosma ernodeoides* Gray	E

Literature Cited*

Fosberg, F.R. 1966. Vascular plants. Pages 153-238 in M.S. Doty and D. Mueller-Dombois, Atlas for bioecology studies in Hawaii Volcanoes National Park. College of Trop. Agric., Hawaii Agric. Exp. Station, Misc. Pub. #89.

Mueller-Dombois, D. 1966. The vegetation map and vegetation profiles. Pages 391-441 in M.S. Doty and D. Mueller-Dombois, Atlas for bioecology studies in Hawaii Volcanoes National Park. Coll. of Trop. Agric., Hawaii Agric. Exp. Station, Misc. Pub. #89.

Mueller-Dombois, D., and H. Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley, N.Y. 754 pp.

Rotar, P. P. 1968. Grasses of Hawaii. Univ. of Hawaii Press, Honolulu. 355 pp.

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.

Spatz, G., and D. Mueller-Dombois. 1975. Succession patterns after pig digging in grassland communities on Mauna Loa. Phytocoenologia 3:346-373.

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.

Whitney, L.D., E.Y. Hosaka, and J.C. Ripperton. 1939. Grasses of the Hawaiian ranges. Hawaii Agric. Exp. Station Bull. No. 82, Univ. of Hawaii, Honolulu. 141 pp.

* Includes literature cited for previous paper, "Hilina Pali Fire of 1975," by same author.