Grazing Land Problems, Molokai Island, Territory of Hawaii

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Introduction

RANGE cattle production is the second largest industry on Molokai Island in Hawaii. Ranchers who run cattle on the grazing lands of the island have many of the same problems that occur on the western ranges of the United States. On the lowlands of the island poor rainfall distribution and high winds are factors limiting forage production. In the highlands, aggressive, unpalatable brush species constitute a major problem in grassland management.

Within a distance of a few miles rainfall often varies from less than 15 inches to over 150 inches per year. Four to five plant zones often occur at levels within a short distance, each with its distinctive plant community.

Lack of effective absorption of rainfall by the soil on the grazing lands is a critical factor today. Good range management, which includes reseeding and sound conservation measures is demonstrating, although somewhat slowly, that a more effective use of the rain can be realized.

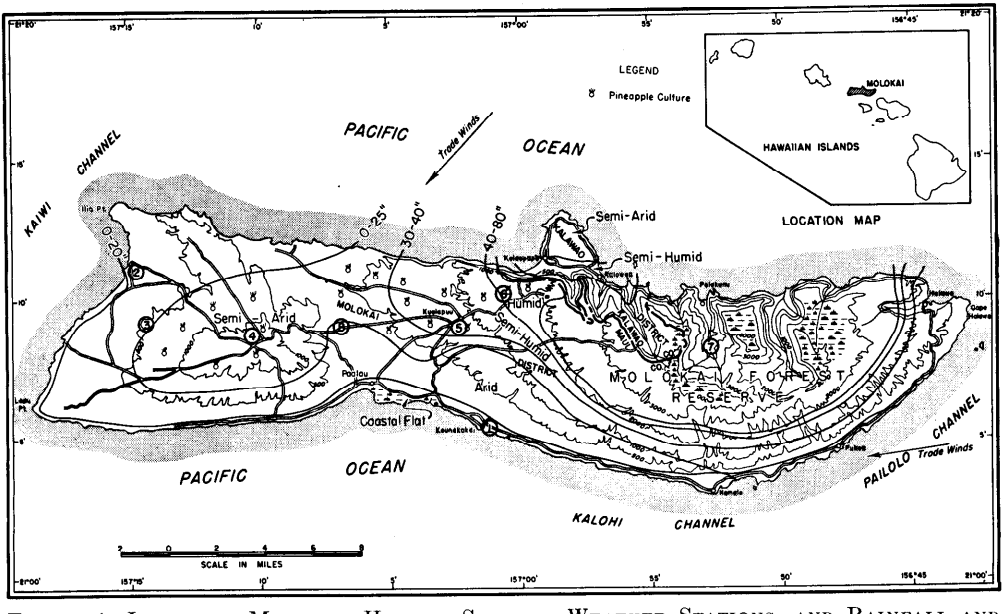

FIGURE 1. ISLAND OF MOLOKAI, HAWAII, SHOWING WEATHER STATIONS, AND RAINFALL AND VEGETATION ZONES

Location

Molokai Island lies about 21° north of the equator, in the same latitude as Cuba. It is one of the smaller islands of the Hawaiian group, covering about 264 square miles (Fig. 1). It is about 7 miles

[1] At present with the U. S. Army.

wide and 36 miles long. The main axis lies approximately due east and west. The highest point, Kamakau Peak, is a little under 5000 feet. The greater part of the land lies between sea level and the 1000 foot contour.

Geology and Soils

Molokai, like the other Hawaiian Islands, is of volcanic origin—the periods of volcanic activity in past ages have occurred over wide intervals. Results of three of these periods can be identified by two major outpourings followed by a lesser one. Geologically speaking, West Molokai, the low part of the island, was formed first. This area has now eroded down to elevations of less than 1300 feet. The next volcanic activity formed what is now known as East Molokai, which has eroded down to an elevation less than 5000 feet. The northeast side of the island is bounded by precipitous cliffs, dissected by a number of steep, short, narrow valleys. The southerly slopes, long and uniform, are cut by many deep, steep-sided gulches.

Following the ancient periods of volcanic activity and subsequent senescence, the plains, locally called Hoolehua, were formed by erosion of the higher lands and by the raising of the mid-section of the island from the sea. The third volcanic episode was a comparatively small one. It formed a 2500-acre peninsula in the sea below the steep cliffs of the north side of Molokai Island proper. This peninsula is the site of the leper settlement (Carlson, 1951). It is virtually isolated from the rest of the island by cliffs 1600 to 2000 feet high.

The ashy and basaltic soils vary considerably in texture and depth, most of them are typically red in color. These soils show little or no profile development. Along the west and lee coastline are alluvial flats, which are underlain with brackish water. Above the alluvial soils, north and east towards the highlands, the soils vary from shallow to deep and are often rocky. In the center of the island and towards the eastern mountains, the soils are deeper red in color and typically show little profile development. The highest elevations have shallow soils with a low pH and a high organic content.

Weather

Although there are two major rainfall patterns during each 12-month period, precipitation varies greatly within a short distance. There is a wide variation between total precipitation from year to year. Table 1 shows the average and the wide variation in yearly totals from the driest (low) to the wettest (high) year on record.

TABLE 1

Yearly rainfall in inches at weather stations, from U. S. Weather Bureau data (15–45 yrs.)

	STATION*					
	1	2	3	4	5	6
Low	3.31	6.16	5.22	12.63	15.44	32.07
Av.	11.70	13.24	23.83	26.75	32.52	45.29
High	23.50	24.20	31.49	40.58	59.32	74.88

* Station 7 had an average of 93 inches.

The kona storms, of which the Hawaiians speak, are major storms that come in from the south and often drop huge volumes of rain. They occur once or twice a year and may drop 8 to 10 inches of rain within a few days. These storms are island-wide, and normally occur between October and April. The violence of the kona storm is indicated by the phenomena of the ocean surrounding two-thirds of the island being colored red for a considerable distance out from shore as a result of the soil washed to sea by each heavy rain.

The trade-wind rains are more local in character, and occur through the year. They come in from the northeast and drop most of their moisture in the northerly windward highlands, seldom on the southern or lee side of the island. The greater part of the yearly rainfall in the highlands is from the trade-wind rainstorms.

A third type of rainstorm is the naulu, which is similar to the thunderstorms of the Great Plains in the States. A naulu of cloudburst proportions can occur at any season. It appears to have no pattern and falls erratically as to locality, time, and volume.

The trade winds, often of high intensity and of yearlong duration, dissipate much of the effectiveness of light rains, which they sometimes bring in. From data compiled from the U. S. Weather Bureau, the main percentage frequency of surface winds at Station 8 (Fig. 1) was as follows: trade winds (northeast to east) from 4 to 12 miles per hour occurred 20.8 percent of the time; and from 13 to 24 miles per hour occurred 44.4 percent of the time. Characteristically, these winds continue following precipitation and dry the surface soil rapidly. The green plants, under heavy winds after the rains, turn brown rapidly thus indicating a too rapid transpiration loss and a depletion of available soil moisture.

Yearly temperatures average about 72° F. From data compiled from the U. S. Weather Bureau, the seasonal variations in mean monthly temperature in Fahrenheit degrees, at Station 4 (Fig. 1) were as follows:

Jan.	Feb.	Mar.	Apr.	May	June
68.6°	68.6°	69.3°	69.4°	71.4°	73.7°
July	Aug.	Sept.	Oct.	Nov.	Dec.
74.2°	75.2°	74.6°	73.7°	71.2°	70.3°

The mean annual temperature was 71.7° F. Slight seasonal variations have relatively little effect on plant growth.

Vegetation

Vegetation, as might be expected, is markedly influenced by the rainfall pattern and exposure to the prevailing winds (Ripperton and Hosaka, 1942.) Elevation, except as it affects rain, evaporation and wind, appears to have little effect on either kind or volume of vegetation.

Land Use

Agriculture is by far the island's major industry. The major income is from pineapple production on about 18,000 acres of the best lands that lie in the 25- to 50-inch rainfall zone. These lands extend from about the center of the island to within three miles of the west shore. There are also a few small vegetable, taro, and fruit growing farms, totalling about 500 acres.

A sizeable, but secondary source of income, is from livestock. The island has about 115,000 acres of grazing land. In addition about 35,000 acres of protected watershed have been set aside from which cattle are excluded.

History of Grazing Use

Prior to the discovery of the islands by Capt. Cook in 1778, the only herbivorous animal was the pig. The pig was brought to the islands many centuries ago by the Hawaiians. The pig is a limited herbivorous animal and it can be said that the island vegetation would be untouched by grazing animals. In 1853 it is reported that there were 200 head of cattle in Molokai. From that time, cattle and the sheep, goats and horses brought in increased steadily up to 1910. Since 1910 there has been a gradual decrease in livestock numbers.

Unregulated, season-long grazing by

larger and larger numbers of livestock after they were introduced, rapidly changed the aspect and composition of the plant cover. Today, many of the more palatable native and introduced forage plants have been replaced by less palatable species. The vegetation of the grazing lands is now very different from the original cover.

The first cattle introduced were long-horns. With the long-horns came many of the ills that often beset the herdsman the world around. An interesting story is told of cattle rustling in 1857, at the village of Palaau (Cooke, 1949). The overseer for King Kamehameha V, about the mid-century, noted the lessening numbers of stock at Palaau and upon investigation found that the whole community was in the cattle rustling business. The rustlers were apprehended, convicted, and sentenced to five years in jail on the nearby island of Oahu. The women and children of the convicted rustlers chose to accompany them, with the result that the Palaau settlement was deserted.

The long-horns were later replaced by purebred Devons, which in turn were replaced by Herefords. Present indications are that these may be supplanted by the "Braford," a mixture of Brahma and Hereford. Hides, tallow, and wool were the first livestock products sold. Today, with refrigeration, the production of high quality meat is the principal source of income.

In 1907 the Molokai Ranch, Kaunakakai, sheared 17,000 sheep. At present there are probably less than 100 sheep on the island. Goats, too, were released in early days and denuded great areas on Molokai. There are only a few half-wild goats left at this time. Deer were released and they now number over 1000, and range in the kiawe-covered, dry zones of the west end of the island.

The first livestock were allowed to roam at will and under the peculiar customs of the day, slaughtering was not permitted under pain of death. Under these circumstances, as might have been expected, numbers increased far beyond the grazing capacity of the range. Trees died out, streams dried up, range forage became scanty and of poor quality, and erosion reached severe proportions on extensive areas of the island. About 1910 the seriousness of these conditions was recognized and stock numbers have since been reduced, but, unfortunately, not fast enough to stop the downward trend of the rapidly declining range. New forage and cover plants have been introduced, but these have not spread rapidly under continued grazing and the aggressive competition of non-palatable plants. Erosion is still a major problem over extensive areas.

Range Sites

Five distinct range types, based on rainfall zones (Fig. 1), have been recognized in the range conservation work.

RANGE SITE	RAINFALL	PREDOMINANT VEGETATION
1. Coastal flat...	0–20″	Kiawe
2. Arid.....	0–25″	Kiawe-Grassland
3. Semi-arid.....	20–35″	Lantana
4. Semi-humid...	30–40″	Guava
5. Humid.....	40–80″	Guava-Ohia-Fern

Each zone has an identifiable flora (Table 2) with particular grazing requirements for proper use.

Coastal flat

The coastal flats are narrow strips of relatively flat land between the ocean and the toe of the hills. There are about 3500 acres of these lands.

An interesting zonation of vegetation is found along the outer fringes of the coastal flats where mangrove covers the

TABLE 2

List of more important range and pasture plants of Molokai Island, showing relative forage value, origin, and zone of importance

SCIENTIFIC NAME	LOCAL OR COMMON NAME	RELATIVE VALUE	ORIGIN	COASTAL FLAT	ARID	SEMI-ARID	SEMI-HUMID	HUMID
Grasses								
Andropogon barbinodis	fuzzytop	Good	Introd.		X	0		
Andropogon pertusus	beardgrass, pitted	Fair	Introd.		0	X		
Axonopus affinis	carpet grass	Fair	Introd.			0	0	X
Cenchrus echinatus	sandbur	Fair	Introd.	0	X	X		
Chloris gayana	rhodes grass	Good	Introd.	0		X		
Chloris inflata	fingergrass, swollen	Poor	Introd.	0	X			
Chloris virgata	fingergrass, feather	Good	Introd.	0	X	X		
Chrysopogon aciculatus	pilipiliula	Poor	Native			0	X	
Cymbopogon refractus	barbwire grass	Pest	Introd.			0	X	
Cynodon dactylon	Bermuda grass, giant	Good	Introd.		0	X	0	
Digitaria pruriens	kukaipuaa	Good	Introd.			0	X	0
Eleusine indica	wire grass	Poor	Introd.	0	0	X	0	
Eragrostis amabilis	hakonokono	Fair	Native	0	X			
Heteropogon contortus	pili grass	Fair	Native		X	0		
Melinis minutiflora	molasses grass	Good	Introd.		0	X	X	
Panicum maximum	guinea grass	Excellent	Introd.	0	0	X	0	
Panicum torridum	kakonakona	Fair	Native	X	X	0		
Paspalum conjugatum	hilo grass	Fair	Introd.				0	X
Paspalum dilatatum	paspalum; Dallisgrass	Excellent	Introd.			0	X	0
Pennisetum ciliare	African foxtail	Fair	Introd.	0	X	0		
Pennisetum clandestinum	kikuyu grass	Good	Introd.			0	X	0
Setaria geniculata	foxtail, yellow	Poor	Introd.			0	X	0
Setaria verticillata	foxtail, bristly	Poor	Introd.	X	0			
Sporobolus capensis	rattail grass	Fair	Introd.			X	X	
Trichachne insularis	sour grass	Pest	Introd.		0	X	0	
Tricholaena repens	redtop, Natal	Fair	Introd.		0	X	0	
Shrubs and broad leaved herbs								
Acacia farnesiana	klu	Pest	Introd.			X		
Amaranthus spinosus	amaranth, spiny	Pest	Introd.	0	0	0	X	
Atriplex semibaccata	saltbush, Australia	Fair	Introd.	X	X			
Batis maritima	beach akulikuli	Pest	Introd.	X				
Bidens pilosa	pilipili	Good	Introd.	0	0	X	X	
Cassia leschenaultiana	Jap tea; partridge tea	Poor	Introd.			X	X	
Crotalaria incana	rattle pod, fuzzy	Poor	Introd.		0	X	0	
Desmanthus virgatus	desmanthus	Fair	Introd.			X		
Desmodium uncinatum	clover, Spanish	Excellent	Introd.		0	X	0	
Emex spinosa	emex	Pest	Introd.	0	0	X		
Emilia sonchifolia	pualele, red	Fair	Introd.	0	0	X	X	
Eupatorium adenophorum	pamakani	Pest	Introd.				X	X
Indigofera suffruticosa	indigo	Poor	Introd.		X	X		
Lantana camara	lantana	Pest	Introd.		0	X	0	
Leucaena glauca	koa haole	Excellent	Introd.	X	X	0		
Medicago hispida	bur clover	Good	Introd.	0	X	X	X	
Metrosideros collina	ohia lehua	Tree	Native				0	X
Phaseolus lathyroides	pea bean, wild	Fair	Introd.			X	0	
Plantago major	laukahi	Poor	Introd.			X	X	
Prosopis chilensis	algoroba, kiawe	Fair	Introd.	X	X			
Psidium guajava	guava	Pest	Introd.			0	X	0
Schinus terebinthifolia	christmas berry	Pest	Introd.				X	
Sida fallax	ilima	Fair	Native	0	X	0		
Waltheria indica	uhaloa	Poor	Introd.	0	X	0		
Xanthium saccharatum	cocklebur	Pest	Introd.	0	0	X		

X—Plants plentiful, growing in communities or clumps
0—Scattered, not growing in communities

wettest areas, and a saltwort, (*Batis maritima*) grows on the drier, salty soils. Inland, the vegetation consists of kiawe (*Prosopis chilensis*) and annual grasses and weeds.

The annual rainfall in these coastal

areas is usually under 20 inches. This may fall in one or two kona storms.

Fertile topsoil, eroded from the higher slopes, has been deposited to depths up to six feet on some of these flats. In a few pockets the soil is highly colloidal and holds water so tightly that very little moisture is available to plants for more than a few weeks after the heavy rains. A few localized areas on the flats are rocky.

On the better drained soils of the coastal flats, even when close to the sea, the kiawe often is impenetrable and of tree size. Kiawe (mesquite to a Texan, or algaroba to a South American) was introduced on the coastal flats of the islands about 125 years ago (Wilcox, 1910). It has now spread from the coastal flats across the island to the uplands. Kiawe stands are so dense on the better soils that few competing plants can grow beneath them. Where the stand of kiawe is open, understory plants grow only after each kona storm. These include such annuals as bristly foxtail (*Setaria verticillata*), swollen finger grass (*Chloris inflata*) and kakonakona (*Panicum torridum*). A few perennials also grow where the shade is not dense and there is sufficient soil moisture. The most important are ilima (*Sida fallax*) and saltbush (*Atriplex semibaccata*). These perennials remain green a little longer than the annuals. Except for scattered clumps of guinea grass (*Panicum maximum*), that sends its roots down to ground water, the rest of the vegetation under the kiawe is made up of coarse, relatively unpalatable weeds. Cattle will graze the understory vegetation lightly, at the season of the year when they are eating the ripening kiawe beans.

Uncrowded kiawe trees produce an abundance of long pods, well filled with beans, which are eaten by the cattle from early July until the first kona storms in October or November. Under present conditions, aside from the dry, understory vegetation, the kiawe pods and beans are the only feed available to the cattle during the late summer and early fall. On this diet, cattle often develop a sickness which affects the nerves and stomach. Once affected, the loss of flesh is rapid and many cattle die. If green grass is supplied, even for only a portion of each day, losses can be avoided through the latter part of the period when the animals are subsisting on kiawe beans.

The coastal flats, when not too saline, will produce some green grass and hardy legumes. This has been demonstrated on the small neighboring island, Lanai, where strips of kiawe have been cleared and planted to guinea grass and a fairly palatable shrub legume, koa haole (*Leucaena glauca*). Satisfactory stands of grass can be maintained if properly irrigated until established and then grazed properly. Sickness due to kiawe bean diet has been markedly reduced on Lanai island by supplying some grass and legume pasture during the "bean" season.

One hundred acres have been cleared of kiawe at the Molokai Ranch, and a sprinkler irrigation system has been installed. Rhodes grass (*Chloris gayana*), and hairy peruvian alfalfa furnish satisfactory pasture. This indicates that where sufficient fair quality water is applied to secure continuous growth, pastures can be established under the prevailing semitropical yearlong temperature. These pastures carry from two to two and one-half head per acre yearlong. The cost of installing irrigated pastures is high, but so are the returns.

Molokai ranchers believe that much of the coastal flat area which is not too salty and where water is available will eventually be cleared for irrigated pasture. Where irrigation water is not available, these ranchers plan to use machinery to open up the thick kiawe stand to permit seedings of dryland perennial grasses.

A number of forage plants in a small grass nursery located on the lee shore in the kiawe area are now under observation. Hopes are held that some adapted perennial dryland species may be discovered which will grow under and between the kiawe trees on the lands where irrigation is not possible.

Arid zone

The arid zone, lying just inland from the coastal flats, is characterized by a sparse to a heavy stand of shrubby to tree size kiawe with an understory of pili grass (*Heteropogon contortus*), annual grasses and shrubby weeds (Egler, 1947). In these grassland ranges, kiawe, the invader, often grows so vigorously that dense thickets have become established—so dense that all competing vegetation is smothered. For the short, winter, green period, ten acres of this poor range are required to support a cow for a month. However, on the better soils, where kiawe trees are in scattered stands, the understory consists of pili grass, annual swollen finger grass, kakonakona, ilima, and uhaloa (*Waltheria indica*).

Some kiawe occurs even on range in excellent condition, but the trees are large and scattered (Fig. 2A). Here the understory annual grasses give way to the shallow-rooted perennial, pili grass, and deeper-rooted fuzzytop (*Andropogon barbinodes*). Rattlepod (*Crotalaria incana*) and Jap tea (*Cassia leschenaultiana*), both legumes, grow intermingled with the grasses, but are relatively unpalatable. The yield of grazable forage on the deeper soils is high. One to two acres of this range in excellent condition will feed a mature cow for a month and still leave sufficient residue to control erosion.

This zone receives less than 25 inches of rain, much of which may fall within two weeks. The prevailing trade winds strike continuously, adding further to the aridity of these lands. Grass stems and tree growth show affects of these winds (Fig. 2A).

The soils of part of this zone are fertile and generally deep. Many acres, however, are severely eroded. The deeper soils would grow adapted cultivated crops if the precipitation was more dependable. The best condition range now is found only on the steep, rocky lands that are more or less inaccessible to livestock.

Customarily, cattle graze these ranges yearlong even though the forage is green only three to six months. The length of the green period depends on the distribution of rainfall. Due to continued, heavy grazing in the past, most of the species now found are comparatively shallow rooted. Deeper rooted perennials could well be introduced so as to use the available deeper water. Fuzzytop, which has a deeper root system and higher palatability than pili grass, is spreading over some of these arid lands. Some effort has been made to establish African foxtail (*Pennisetum ciliare*), which greens up quickly after each rain. This grass has a strong root system. Pitted beardgrass (*Andropogon pertusus*), also deep rooted but of comparatively low forage value, is invading some areas. Giant Bermuda grass (*Cynodon dactylon*) is growing in the favored spots, though it is marginal and does not produce as much feed as desired. Guinea grass grows in scattered clumps, but it is so palatable that it is easily grazed out. A desirable palatable legume has not yet been found for these lands.

Adequate grazing distribution is also a problem. Water is brought in from the mountains two to twenty miles by pipeline, with further distribution from tanks to troughs in the pastures. Construction of additional stock watering facilities where they would aid in more even grazing and reduce trailing is needed.

The Molokai Soil Conservation District, cooperating with the largest cattle ranch on Molokai, has developed a deferred rotation system of grazing that appears to be well suited to arid lands of this ranch. Under this system the grazing of large numbers of cattle for short periods in systematic rotation promotes a more even use and gives the range a better chance to develop vigorous plants and to reseed.

A forage improvement program has been initiated on this ranch for the sites adapted to reseeding. Successful reseeding is difficult, however, because of the erratic rainfall pattern and strong drying winds. A cultipacker seeder used after preparing a seedbed by subsoiling and

FIGURE 2. ARID AND SEMI-ARID ZONES

A. Arid kiawe-grassland, excellent condition range, deep red soil. Kiawe tree with guinea, fuzzytop, pili, and other grasses. B. Semi-arid range, fair condition, deep to shallow soils. Small guava and lantana brush with Dallisgrass, Bermuda grass, and rattail.

discing had been tried with fair success for the first time in 1950. In former trials, grass seeds were broadcast and results were disappointing, except for feather fingergrass (*Chloris virgata*) which, while aggressive and palatable, is an annual. Deep furrow drills also should be given a trial.

Kiawe should be eliminated from larger portions of these range lands so as to conserve moisture for the seeded grass.

The range improvement program on this ranch, consisting of reseeding, deferred rotation grazing, careful adjustments of stocking, and brush control, is designed to reduce erosion and increase the forage. Rapid improvement is expected when the selected deep soil areas are reseeded to carry a portion of the grazing load from the range now in poor condition.

Semi-arid zone

This is a transition zone for most plants, in that plants found may be common to either the arid or the semi-humid zones. Elevation varies from a few feet above sea level to 2500 feet.

Soils in this zone, while fairly fertile, are very uneven in depth. As is typical, the soils show little profile development. High winds and overgrazing have caused bald spots through this zone. It is difficult to establish vegetation on these bald spots unless given special treatment, such as mulching, ridging, or irrigation. In this zone there also are a few extremely shallow, heavy textured soils, locally called paapakaia, where it is also difficult to establish grazable vegetation.

The total rainfall should be sufficient to produce a fairly satisfactory forage cover, but is so erratic that results are spotty. The kona storms supply a part of the yearly total; trade-wind storms supply 25 to 50 percent. Here, as on the arid sections, the frequent winds reduce the possible beneficial effects of the intermittent rainfall—though the winds, except in a few hilltop areas, are not as continuous as they are in the arid zone.

There seems to be no grass or weed growing in this zone that dominates the other vegetation. The brushy lantana (*Lantana camara*) is an aggressive pest that flourishes on the best soils (Fig. 2B). It produces a cover so heavy that little else grows with it. Klu (*Acacia farnesiana*), a worthless spiny leguminous shrub, and koa haole, are found in the lower elevations. Small guava (*Psidium guajava*) also invade on the better soils. Bermuda grass and guinea grass do well in this zone when the aggressive invader shrubs can be controlled. Paspalum (*P. dilatatum*) does well, as does Natal redtop (*Tricholaena repens*), while molasses grass (*Melinis minutiflora*) has the virtue of establishing itself on the poor (paapakaia) soils. Other grasses are kikuyu (*Pennisetum clandestinum*), annual fescues, and bromes. Rattail (*Sporobolus capensis*), (Whitney, 1939), fuzzy-top and pitted beardgrass invade where competition is light. Sour grass (*Trichachne insularis*) is an aggressive perennial invader, but is unpalatable to livestock.

There are many weeds and forbs in this zone. Bur clover (*Medicago hispida*), mustards, *Amaranthus* sp., *Bidens* sp., and Jap tea are present. Spanish clover (*Desmodium uncinatum*) is a promising legume now on trial which appears to be not only excellent feed, but has the unusual ability to maintain itself in this environment. However, it has been slow to establish.

The season of green feed in this zone, usually five to eight months, is regarded as favorable. The trade-wind rains help keep the forage growing, though in ex-

posed spots the continuous winds dry up the forage in a short time, when more than a few days elapse between rains.

The reseeding of range and pasture forage plants in this zone is profitable. Lantana can be eliminated and the land planted to guinea grass, Bermuda grass, and kaimi clover.

Grazing distribution on the seeded pastures in this zone is not a serious problem as most of the units are small. Many acres of these seeded pastures, heavily overstocked in the past, will require clearing of brush and reseeding to develop full forage yields. Deferred-rotated grazing is indicated during the growing season. Grazable growth for eight months of the year is not unusual. One acre of good pasture will supply feed for one to two cows a month. Six to twelve acres are needed per year per cow.

Semi-humid zone

The yearly rainfall in this zone varies from about 30 to 40 inches. Elevations range from 500 to 2500 feet. The areas of good soils give excellent returns when cleared and planted to good forage species.

Soils are generally deep and fertile in the drainage bottoms. Adjacent gentle slopes, although rocky in spots, are also fairly productive. The benchlands, while often too shallow for pineapple, support good stands of grass (Fig. 3A). Erosion is not a serious problem on these lands because there is a generally good plant cover during critical periods.

The shallow soils on the steep slopes usually are covered with a short growth of guava, pilipiliula (*Chrysopogon aciculatus*), paspalums, molasses grass and weeds. Grazing on these slopes should be only moderate, especially when the area is composed largely of molasses grass. Molasses grass forms an excellent cover here, but invariably it is killed out by overgrazing and is replaced by less palatable plants which are difficult to eradicate. Because of shallow soil, there is some danger of severe erosion losses when the land is overgrazed, even temporarily, before a new cover of vegetation grows.

Guava and similar shrubs grow rank and shade out the forage plants once they gain a foothold on the benchland. Certain groups of these shrubs, whether grazed or not appear to grow in ecologic balance. In order to establish good forage plants on these soils, it is necessary to remove the shrubs. In drainage bottoms, guava grows to tree size, frequently so thick that livestock cannot penetrate the stand. Following the removal of the shrubs, kikuyu grass can be sprigged in on the better soils, molasses grass planted on the shallower soils and a range established, which can be maintained under good grazing management. If the land is planted in November, usually it can be grazed moderately the following July. Kikuyu is not regarded as the best forage plant, but is palatable and aggressive enough to keep out the shrubs if the first of such invaders are removed by hand. Bermuda grass also is being tried and shows some promise on the deeper soils. Dallisgrass is another excellent plant that is easily established, but it does not have the soil holding and water retarding capabilities of the other grasses. Kaimi clover grows well in this zone where it is now planted; more will be used as more seed becomes commercially available.

The big problem on these lands is that of brush control. Good stands of kikuyu grass, when established can be grazed almost yearlong. If care is used in grazing kikuyu, it will not become rank and unpalatable. The best solution to the problem of keeping kikuyu grass ranges properly grazed is to fence smaller paddocks

and rotate their use with larger numbers of animals.

FIGURE 3. SEMI-HUMID AND HUMID ZONES

A. Semi-humid zone, deep to shallow soils. Kikuyu grass on bottoms and benches, excellent to good condition. Guava and lantana slopes with fair to poor condition pasture. B. Humid zone, poor condition pasture. Shallow soil with low pH. Ohia lehua and tree ferns dying. Overgrazed carpet grass and hilo grass.

A secondary problem is that of controlling the invasion of the relatively unpalatable perennial yellow foxtail (*Setaria geniculata*). The seeds of yellow foxtail are numerous and wherever there is a bare spot the plant grows rapidly. Proper management and a good tight cover of desirable plants will keep the yellow foxtail out of the pasture.

These "mauka" (mountain) pastures,

while limited in area, give good returns and help round out the grazing program for ranches situated so as to use them economically. Three to six acres of good, highland or foothill pasture carefully grazed will feed a mature cow yearlong.

Humid zone

The humid zone receives about 40 inches or more rainfall, well distributed throughout the year. The climate is cloudy and foggy much of the time. Soils vary sharply from deep to shallow with some of them poorly drained and most of them definitely acid. Many of the soils have a very high organic content.

These highlands were heavily forested prior to Capt. Cook's discovery of the islands. Guava grows on some of the land, but it is not as vigorous as it is in the semi-humid zones. Ohia (*Metrosideros collina*) and other shrubs and trees and many ferns cover the slopes on the shallower, more acid soils. Ferns and hilo grass (*Paspalum conjugatum*) dominate the more open areas (Fig. 3B).

Little work has been done toward rehabilitating these highlands for grazing. Kikuyu, molasses grass and Dallisgrass as well as the clovers may do well under this environment. Alta fescue has been suggested as a promising grass.

Year round grazing on these lands would appear feasible if the brush were cleared off and seeded to adapted forage species.

Watershed

A forest reserve lying to the north, northeast, and east of grazing lands described is maintained for the protection of the upper watershed. There are areas of grass in the forest reserve, but livestock are excluded because of the fear of damage from overgrazing.

There are large swamps in the reserve which hold quantities of water and at the same time allow it to move slowly oceanward. Most of the drainage of the reserve is toward the northern shore.

Brush covers extensive areas. Trees are small to medium size. The understory of grasses, weeds and ferns varies from sparse to heavy.

The valleys on the northeast side of the island might support livestock, but they are inaccessible except by water, and the sea is generally so rough that most ranchers are discouraged in trying to land on the beaches near them. Liver fluke is common in the wetter areas. Rice and taro were formerly produced in these valleys and shipped out by boat. The last work oxen from the abandoned ranches were reportedly shot several years ago. No people have moved back to these fertile but inaccessible valleys in recent years.

Summary

Molokai is a small island lying at about 21° N latitude. Rainfall may vary from less than 10 inches per year to over 150 inches, within short distances. Rainfall occurs as heavy storms on the arid sections, or throughout the year on the humid sections. Winds generally are constant and often severe.

The island is of volcanic origin, and while the soils vary in rockiness and depth these variations do not seem to markedly affect the plant species within the rainfall zone.

Pineapples are grown on the better arable lands in the semi-arid zones. The remainder of the island is used for grazing cattle and as a protected watershed to assure needed water supplies for lower lying lands.

Before the white man came there were no herbivorous animals, except the pig, on the island. The vegetation consisted mainly of species unpalatable to animals. Now, after years of cattle, sheep and

horses, the plant cover has changed. Most of the forage plants on the range today are not native and have been introduced from many parts of the world. Some of these plants are valuable and some are pests.

In order to better analyze the grazing problems, the island has been divided into five sites (rainfall zones) from arid to humid. Each supports identifiable plant groups and each presents problems peculiar to its zone. The challenge is to reseed the best species suited to each particular zone and follow up by applying the best known grazing management.

Range conservation plans on the ranches of the Molokai Soil Conservation District provide for clearing, reseeding and planned grazing. As the ranges and pastures are improved, resulting in better land use, more meat will be produced and a better living will be realized by the ranchers.

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A CHANGING CREED

For three hundred years we built a great civilization, and developed a high standard of living by the techniques of expansion, exploitation, and speculation. Our undeveloped natural resources were so great and our population so small that we succeeded beyond our wildest hopes. A belief in expansion, exploitation, and speculation became our creed. But gradually, imperceptibly, things changed. We changed them by following our old creed to the point where it was proved to be a fallacy. Now our creed is changing, changing to a belief in the need for conservation and a desire for security.—*Dr. Carl C. Taylor*, in Journal of Soil and Water Conservation, July 1950.