Grazing, Fire, and the Management of Vegetation on Santa Catalina Island, California[1]

Richard A. Minnich[2]

Abstract: 19th century ground photos and aerial photographs reveal that chaparral and coastal sage scrub on Santa Catalina Island resembled modern stands on mainland coastal areas ca. 150 years ago, but were converted into an open herbaceous savanna due to overgrazing by feral goats, pigs, and other exotic fauna. This transformation has limited fires due to continuous removal of fuels. Browsing has also modified the floristic composition of brushlands. Removal of feral herbivores will result in rapid vegetal recovery and increasing fire danger.

Santa Catalina Island, located 70 km south of Los Angeles, California has experienced a limited history of fires during the 20th century. This is due primarily to continuous grazing and denudation of chaparral, coastal sage scrub and herbaceous fuels over the past 150 years by feral goats, pigs, and other exotic fauna. This trend is an extraordinary anomaly in southern California's mediterranean climate where fire is an annual possibility in most wildlands. Unfortunately, the present "solution" to the fire problem is accompanied by a multitude of other problems. These include island wide erosion, slope failure, destruction of indigenous wildlife, and decline or even extinction of numerous plant species, some of which are or were island endemics (Thorne 1967). Because of the devastation of the island, The Center for Natural Areas[3], under contract with the Los Angeles County Department of Parks and Recreation, has prepared a Natural Resources Management Plan (CNA 1980) on which this study is based. One recommendation of the report is the removal of feral herbivores, especially goats and pigs. Such a plan if implemented will result in increasing fire danger due to the accumulation of fuels in recovering vegetation.

This study documents a vegetation history of Santa Catalina Island by investigating the nature of pregrazing vegetation on 19th century ground photographs; present vegetation as mapped from 1976 color infrared aerial photography; long-term vegetation change as seen from retakes of old photographs, and comparative analysis of 1944 and 1976 comprehensive vertical aerial photography. From these data I speculate on past vegetation change, future fire potential, and management of brushland fuels if feral animals are removed.

GRAZING HISTORY

Grazing became important on Santa Catalina Island soon after attainment of statehood (1850). Commercial sheep and cattle grazing continued on Santa Catalina until the early 1950's when most of the domestic stock was removed.[4] The goat is thought to have been introduced to Santa Catalina during the late years of Mexican occupation (1820-1840, Coblentz 1976). Goats slowly became feral and were left to multiply at will in the absence of indigenous predatory animals. Present populations, numbering about 5000, are most abundant in three areas: the Silver-Grand Canyon drainage system, Gilbralter Rock on the north coast, and on the West End. These were excluded by fencing from interior drainages east of the isthmus in the 1950's. Goats prefer most herbaceous plants. Most chaparral and coastal sage species except for Rhus integrifolia, Malosma laurina, and Salvia spp. are browsed during the summer and fall when herbaceous cover is desiccated (Coblentz 1980). Pigs were introduced from Santa Rosa Island in the 1930's. They most commonly occur in deep soiled areas with dense chaparral cover and which are free of goats (Coblentz 1980). Although the pig is a grazer and browser, its greatest impact on vegetation results from its fruit—eating habits, the thoroughness of which inhibits the reproduction of many woody species.

FIRE HISTORY

Although Santa Catalina Island may be more exposed to maritime influences than mountain ranges on the southern California mainland, it is still subject to summer drought, desiccation of vegetation, and high fire potential. In spite of these conditions, only a few fires, mostly less than 10 hectares, have occurred in

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[2]Assistant Professor of Geography, University of California, Riverside, Calif.

[3]South Gardiner, Maine

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recorded times. This trend contrasts sharply with the fire history of the mainland where thousands of hectares are burned each year, and the accumulative fire frequency over several million hectares of coastal sage scrub and chaparral averages once every 30 to 40 years (Hanes 1977; Minnich 1978). The most compelling evidence for the fire potential on the Channel Islands comes from the summer of 1979 when 7,000 ha were burned on nearby San Clemente Island. All but 1500 goats had been removed from San Clemente during the middle 1970's.

PRESENT VEGETATION

A vegetation map of the island was interpreted from 1:22,000 color infrared photography taken by overflight in February, 1976. The map was digitized according to physiognomic class. Polygons were then correlated with other digitized data including elevation, slope, aspect, soil depth, and erosion (Table 1).

General Vegetation Features

The vegetation resembles most overgrazed landscapes of the world (see Mooney and Conrad 1977). Indigenous woody cover is predominantly a small tree savanna with continuous herbaceous understory, strikingly reminiscent of the oak woodlands found in coastal central California (Minnich 1980). The prevailing plant communities include annual grassland, coastal sage scrub, chaparral, and woodlands (see Barbour and Major, 1977).

European grasses form the major portion of the total plant cover. They thrive best in deep loamy soils on alluvium, marine terraces, or gentle surfaces, but may even prevail on steep rocky slopes. Density and cover varies significantly depending on grazing patterns but occurs in gradients having little correlation with fencing, owing perhaps to the territorial behavior of goats (Coblentz 1976).

Coastal sage scrub is relatively uncommon (20 percent of island cover) compared with its abundance in the coastal mountains of mainland southern California (Mooney, 1977). This community occurs on steep south and east facing slopes with little or no soil. Contiguous stands reminiscent of the mainland (0.5-1.5 m tall; greater than 70 percent cover) are widespread in the vicinity of Avalon. In more heavily grazed areas coastal sage scrub becomes increasingly degraded, fragmented, and admixed with Opuntia littoralis. Field observations indicate that Artemisia californica and Eriogonum giganteum thrive best in areas protected from goats. Salvia apiana and S. mellifera are dominant elsewhere.

Evergreen sclerophyllous scrub or chaparral rarely forms extensive stands except on north facing slopes and in canyons. Only one third form contiguous cover. The remainder exist in parklands of mostly tall shrubs with sharp browse lines, underlain by annual grassland, coastal sage scrub or Opuntia. Although chaparral tends to cover steep slopes, it is associated with deeper soils, less erosion, and more rapid soil permeability than other communities

Table 1--Summary of Vegetation of Santa Catalina Island (total hectares and percent of total island area for each variable)

Vegetation Type	Total Elevation (ml)				Slope Class (degrees)					Slope Aspect			
	Area	0-183	184-366	>366	0-10	10.1-30	20.1-30	31.1-40	>40	NN,N	NE,E	SE,E	SW,W
Grassland Coastal	11912	54	63	72	71	69	61	56	54	63	53	59	73
Sage Scrub	3383	20	19	12	10	14	21	21	18	6	23	32	14
Chaparral	2756	15	16	10	8	12	15	20	13	27	21	2	6
Urban, Cult, Bare	1183	11	2	6	11	5	3	3	15	4	3	7	7

Vegetation Type	Depth to Bedrock (m)			Erosion	Slope			Permeability		
	0-0.6	0.6-1.0	>1.0	None-Moderate	Severe	Failure	Flooding	No Soil	Slow	Rapid
Grassland Coastal	58	67	48	59	65	43	43	48	66	58
Sage Scrub	21	11	7	16	20	7	8	23	15	16
Chaparral	13	17	11	20	8	5	14	9	15	17
Urban, Cult, Bare	8	5	34	5	17	45	35	19	4	9

(Table 1). This trend is inconsistent with mainland vegetation where chaparral tends to occupy the steepest and rockiest slope (Wells, 1962). This difference may reflect a long term feedback from overgrazing inasmuch as present deep rooted chaparral stands that have survived continuous browse pressure are responsible for the maintenance of deep soils.

The floristic and age composition of chaparral varies with slope exposure. Rhus integrifolia and Malosma laurina, tend to form open stands on south facing slopes. Juveniles are often seen side by side with old individuals within a single stand. On north facing slopes, chaparral is dominated primarily by Quercus dumosa and Rhus integrifolia. Individuals are typically old, robust, shrubs 5-10 m tall with d.b.h. of 30-50 cm. Stands are open to contiguous, exhibit browse lines 1 to 2 m above the ground, and contain considerable herbaceous understory. In the least disturbed areas adjacent to Avalon Quercus dumosa and Heteromeles arbutifolia are admixed with Cercocarpus betuloides blancheae, Ceanothus arboreus, and C. megacarpus insularis, with embedded patches of Adenostoma fasciculatum. These are mostly contiguous, have minimal browse damage and contain sufficient fuels to induce the Los Angeles County Fire Department to construct fuel breaks. A. fasciculatum and Ceanothus chaparral are surprisingly unimportant on the island, in view of their abundance in mainland California (Hanes 1977). Mesic north facing slopes, canyon, and bottomlands support broadleaf evergreen forests (Prunus ilicifolia lyonii, Quercus chrysolepis, Q. tomentella, and Lyonthamnus floribundes floribundes). The areal extent of this physiognomic type appears to be independent of grazing pressure because many of the best stands occur in areas with heaviest goat populations.

VEGETATION HISTORY

In view of such enduring disturbance, one cannot assume that the present island vegetation represents prehistoric conditions. Woody vegetation was probably much more extensive before the introduction of domestic stock, and perhaps once strongly resembled present day brushlands on mainland southern California rather than as open, "arborescent" woodlands seen now (Minnich 1980). The nature of such transformation to the present pattern is not simple to evaluate. It involves not only the mechanical effects of browse, resultant denudation of woody cover, and disruption of reproductive processes, but also the modification of the natural fire regime due to the continuing harvest of woody and herbaceous fuels. Unfortunately, the aboriginal state of island vegetation is undescribed and vegetation change can be analyzed only from aerial photographic data taken in the present century and a few old ground photographs taken during an otherwise dim past.

Pre-Grazing Vegetation

Although goats were introduced perhaps no earlier than the 1840's and sheep a decade later, most old photographs dating to the 1880's show severe overgrazing and even more widespread vegetation damage than is seen at present (Minnich 1980). Grass cover is clipped or stripped, Opuntia is widespread, coastal sage scrub is nearly absent, and browse-lined chaparral shrubs are widely scattered. A few very early photos may give a glimpse of the nature of pregrazing vegetation. A photo of Mt. Black Jack taken cir. 1885, for example, shows a continuous stand of Adenostoma fasciculatum, with embedded Quercus dumosa, Rhus integrifolia, and Malosma laurina (Minnich 1980). Photographs of the same site in 1900 and 1980 show that Adenostoma had disappeared, leaving a savanna of browsed shrubs, mostly Q. dumosa. Perhaps the most significant photos of pregrazing vegetation on the Channel Islands were taken in the Central Valley of Santa Cruz Island in 1869, only 14 years after the introduction of sheep (Brumbaugh 1980). These photos show south facing slopes covered with continuous low chaparral, dominated by Adenostoma fasciculatum, Ceanothus megacarpus insularis, and coastal sage scrub. Together these resemble present-day stands in the mainland Santa Monica or Santa Inez Mountains. Browse lines are absent and evidence of past fires is reflected in the uniform physiognomy of several stands. Today these areas are covered with grass and scattered oversized shrubs of Quercus dumosa and Cercocarpus betuloides. Coastal sage scrub disappeared altogether.

1944-1976 Vegetation Changes

Comprehensive black and white aerial photography of Santa Catalina Island (scale 1:24,000) flown in 1944 was compared with 1976 color infrared with a Bausch and Lomb Zoom Transfer Scope in order to evaluate shrub dynamics. The photography was sampled at 213 locations approximately two hectares square in area, uniformly distributed over the island. The scale of both imageries was adjusted so that the same plants could be matched. The following was recorded: (1) the number of shrubs in 1944; (2) the number of fatalities since 1944; (3) reproduction since 1944; and (4) the number of plants in 1976. The data presented in Table 2 shows a pattern of increasing shrub cover over wide areas of the island since 1944. Recovery is not so much due to increased reproduction; it is the remarkable lack of mortality since 1944.

Mortality

If 1944-76 mortality rates were extended indefinitely there would be complete removal of 1944 individuals in 523 years for oak chaparral on northern exposures and 928 years for Rhus-

Table 2--Aerial Sample of Combined Shrub Frequency by Area and Slope Exposure for 1944 and 1976

Area	Goat[1] Pressure	Slope Exposure	No. Samples	1944 Plants	1944-76[2] Mortality	Local[3] Mortality Turnover Rate (years)	1944-76[4] Repro-ducton	Repro.[5] Doubling Rate (years)	1976[6] plants	pct.[7] change since 1944
Avalon	-	S	15	960	5	6144	362	85	1317	137
		N	7	365	3	3893	208	63	570	156
Whites Landing	-,o	S	7	405	7	1851	109	119	507	125
		N	10	395	24	525	83	152	454	115
East Channel Slope	o,+	S	6	183	21	468	27	217	189	103
		N	8	392	23	545	30	418	399	102
West Channel Slope	-,o,+	S	6	166	8	664	77	69	235	142
		N	16	569	40	455	10	1820	539	95
West Pacific Slope	o,+	S	6	270	15	872	41	211	296	110
		N	4	106	4	848	6	565	108	102
L. Springs Cottonwood	-,o	S	12	393	18	1048	114	110	489	124
		N	17	779	15	1662	33	755	797	102
Sweetwater-Bullrush	-,o	S	21	967	24	1289	214	145	1157	120
		N	21	855	33	829	94	291	916	107
Salta Verde	-,o	S	7	559	4	4472	70	256	625	112
		N								
Grand-Silver	+	S	11	360	45	256	26	443	341	95
		N	11	409	95	138	13	1007	327	80
Island		S	96	4263	147	928	1040	131	5146	121
		N	95	3870	237	523	477	260	4110	106

1. - = light; o = moderate; + = heavy
2. No. fatalities of plants observed in 1944
3. $\frac{\text{No. plants in sample}}{\text{No. fatalities}} \times 32$ years
4. No. plants observed on 1976 photographs not evident in 1944
5. $\frac{\text{No. plants in sample}}{\text{No. reproduction}} \times 32$ years
6. 1944 plants + reproduction - mortality
7. $\frac{\text{1976 plants}}{\text{1944 plants}}$

Malosma on southern exposures. Post-1944 mortality ranges as high as 20 to 30 percent in scrub oak chaparral in core grazing areas, which is equivalent to a turnover rates of 225-250 years. The implied longevity of chaparral is high, in comparison with the short period of time between defoliating fire events in mainland chaparral. Many chaparral species, however, sprout as many as 20 to 30 times at a fire frequency of ca. 30 years. In this sense they may be equally as long lived as the shrubs on Santa Catalina.

Fatalities usually occurred individually. Vegetation stripping on a mass scale was observed in a few localities with heavy goat pressure. Stripping appears to arise from two processes. In some cases, shrubs too dense for easy goat access are eventually opened up sufficiently to allow rapid browse and denudation. Otherwise, vegetal removal appears to stem from slope failure during heavy winter rains. The resilience of surviving shrubs is clearly due to their existence above the browse line. Smaller plants have little chance. Therefore, it could be argued that present low mortality rates derive from the fact that only the sturdiest plants remain after decades of grazing pressure. The opening up of brush cover reduces competition for water and nutrients. Nutrient cycling and soil enrichment is made more efficient by the browsing of plant material that would otherwise slowly decompose in an arid environment. While Miller (1980) has attributed the dominance

of Quercus dumosa to high soil nitrate, which is no doubt increased by feral herbivore activity, our data contradicts this in that most oaks predate feral grazing. Their dominance is due primarily to their endurance against browsing.

Reproduction

Aerial photographs reveal increases in shrub frequency of 10-30 percent of 1944 levels over much of the island. At 1944-1976 reproductive rates shrub frequencies would double in approximately 130 years on southern exposures and 260 years on northern exposures. Rates vary greatly over the island and correlate inversely with grazing pressure. Reproduction is minimal in goat infested areas. Heaviest reproduction (140-160 percent of 1944 levels) has occurred in the Avalon area and adjoining slopes where urbanization has reduced goat and pig activities. The story elsewhere on the island is mixed. Reproduction tends to be good on south-facing slopes and poor on north facing slopes. New growth on south faces are mostly Rhus integrifolia and Malosma laurina, both undesired by goats and pigs. This seems to confirm Miller's (1980) observation that R. integrifolia abundance is increased by grazing and low fire frequencies. Reproduction in Quercus dumosa stands on north slopes appears to be completely stifled by pig rooting and browsing. Most young plants in this community are Rhus integrifolia and Heteromeles arbutifolia. Adenostoma fasciculatum, Ceanothus megacarpus, and C. arboreus seedlings and saplings are few and far between. This is not surprising since these species are nearly depleted from the island, incapable of long-distance seed dispersal and reproduce best after fire (Wells, 1969; Hanes, 1977).

Long-term brushland recovery is best recorded in Avalon Canyon where slopes have been photographed continuously since the 1880's. An overgrazed landscape of sparse grass, Opuntia, and open, pruned chaparral developed rapidly into coastal sage scrub by 1900, after the resort town was established. Thereafter, chaparral dominated by animal dispersed species, notably Heteromeles arbutifolia and Rhus integrifolia, has invaded at a slower pace, becoming conspicuous on photographs after about 1940.

DEVELOPMENT OF A MANAGEMENT PROGRAM

The potential for wildfire on Santa Catalina Island is small compared to that on the mainland. Nevertheless, under appropriate conditions fire can be supported by the present vegetation over most of the island. European annual grassland burns readily during summer drought as it is 100 percent dead fuel. Browsing pressure reduces the continuity of cover and the possibility of large herbaceous conflagrations. Such would certainly become an immediate problem if feral animals were removed. The tree-like physiognomy and open nature of chaparral enhances the possibility of their escaping ground fires carried by grass or coastal sage scrub. An exception is the vegetation around Avalon. The chaparral is rapidly taking on the physiognomy of mainland stands. Most are contiguous, lack browse lines, and are capable of carrying a Santa Ana wind driven brush fire with intensities comparable to those in coastal mountains of southern California. Ironically, an intense fire would be a death knell to woody vegetation under the present grazing regime. Most brushlands survive now because shrubs reach above the browse line. After fire, seedlings and resprouts would be grazed to destruction. Thus fire can be seriously considered as a management tool only after feral herbivores are removed from the island. Presumably chaparral would redevelop horizontal and vertical continuity similar to mainland stands with the cessation of grazing. Exclosure studies on Santa Cruz Island have demonstrated this trend (Brumbaugh 1980).

The accumulation of fuels attendant with the removal of feral animals will necessitate planning of a vegetation management scheme that prevents or controls severe wildfire while still encouraging further development of woody cover to ameliorate watershed problems. This will require the development of a comprehensive management plan to control wildland fires. There are two basic concepts of fuel management in controlling wildland fire. Greene (1977) has termed these fuel break and block and prescribed mosaic burning.

Fuel Break and Block

Land managers are uncomfortable with the widespread continuous nature of mature chaparral because they are unable to place safely manpower and equipment. Fire fighting agencies constructed a system of fuel breaks which represent lines of type conversion from brush to herbaceous cover, 30-100 m wide. Fuel breaks divide the chaparral into blocks, provide a safety zone for fire fighters, as well as resist the spread of fire from one block to another. The problem with the fuel break and block plan is that the vegetation within the blocks is not managed. Chaparral is allowed to become old, decadent, high in dead fuel content, and highly flammable until the inevitable fire comes. Fire suppression selects for uncontrollable fires in the worst weather because fires in good weather are put out. Therefore, fires easily skip across fuel breaks and end up burning especially large areas which are later subject to erosion and flooding until new growth redevelops. The failure of this approach on the mainland serves as a warning not to implement it on the island as long-term policy (Philpot 1974).

Prescribed Mosaic Burning

As alternative management strategy is to use fire as a tool for managing brushlands. In the long run, the intent of prescribed mosaic burning is to develop a patchwork of different aged stands roughly 200 to 700 ha in size. Such a mosaic was described in southern California in the late 1800's when fires still ran free and may presently be seen in the chaparral of northwest Baja California where fire suppression has never been instituted. The mosaic is the basis of fire control since younger, less flammable growth checks the progress of fires burning in older growth (Philpot 1974). I recommend the implementation of prescribed mosaic burning in the vicinity of Avalon as soon as feral animals are removed. In ensuing decades a fire mosaic should be established over the rest of the island. In the meantime traditional fire suppression practices should be continued until woody vegetation recovers sufficiently to protect the watershed. While it is recognized that the vegetation will not duplicate its pregrazing density or flora, it is anticipated that a healthy shrub community can be reestablished in the regime of periodic fire.

CONCLUSION

It appears that feral grazing over the last 150 years has removed much woody cover on Santa Catalina Island while selecting in particular against the smaller, less durable Adenostoma fasciculatum and Ceanothus megacarpus insularis and most coastal sage scrub species. Salvia spp. have survived to dominant status over small areas of the island due primarily to their impalatability. Chaparral has been more and more confined to north-facing slopes. It is now time to recognize the damage feral animal grazing has done to Santa Catalina Island. The removal of these animals, however, could result in growing fire danger and the potential for further watershed deterioration. Effective reestablishment of brushland vegetation will require a management strategy linking traditional fire suppression and prescribed mosaic burning.

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