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History Of Wildland Fires On Vandenberg Air Force Base, California

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TABLE OF CONTENTS

ABSTRACT

The fire history of the past 50 years for Vandenberg Air Force Base, California was determined using aerial photography, field investigation, and historical and current written records. This constitutes a record of the vegetation age-classes for the entire base. The location, cause, and fuel type for sixty fires from this time period were determined. The fires were mapped and entered into a geographic information system (GIS) for Vandenberg. Fire history maps derived from this GIS were printed at 1:9600 scale and are on deposit at the Vandenberg Environmental Task Force Office.

Although some ecologically significant plant communities on Vandenberg are adapted to fire, no "natural" fire frequency could be determined, since only one fire possibly caused by lightning occurred in the area now within the base since 1937. Observations made during this study suggest that burning may encourage the invasion of exotic species into chaparral, in particular Burton Mesa or "sandhill" chaparral, an unusual and geographically limited form of chaparral found on the base.

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGMENTS

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INTRODUCTION

There are two purposes for reconstructing the fire history of Vandenberg Air Force Base. The first is to determine age classes of vegetation. The combination of highly flammable vegetation types, rugged topography, and variety of ignition sources found on Vandenberg creates a high potential for hazardous wildfires. Recognizing this, a controlled burning program based on the Wildland Fuel Management plan developed for Vandenberg (Wakimoto et al. 1980b) was implemented in 1981 by the base Fire Department. However, no recommendations for the frequency of prescribed burning were given nor were areas prioritized for burning beyond a five year proposed schedule in the report. A fire history would complement the fuel management plan, since age-class information is needed for prioritizing areas to be burned. A knowledge of the location of past fires is also useful in planning wildfire fighting strategy.

The second purpose for the fire history is to provide the background information necessary to develop an understanding of how fires have affected the vegetation patterns on the base. This can be used to determine the optimum fire frequency that may balance reduction of fuel hazard with management practices that maintain the vigor and integrity of native vegetation and wildlife habitat.

Vandenberg contains regionally important vegetation that is fire-dependent. The Bishop pine (*Pinus muricata*) forests in this area are discussed by Zedler (1977) and Vogl et al. (1977). The fire ecology of chaparral, which is abundant on base, has received considerable attention in the literature (e.g., Sampson 1944, Sweeney 1956, Hanes 1971, Vogl 1982); aspects of this fire ecology are reviewed by Schmalzer et al. (1988). Burton Mesa chaparral, a form of maritime chaparral that occurs on Vandenberg, is discussed in Ferren et al. (1984), Griggs (1980), Holland (1986), and Hickson (1987a); its significance is evidenced by numerous environmental documents concerning developments in the area (e.g., Howald et al. 1985, Howald and Davis 1986, Interface 1987). The importance of fire in coastal sage scrub, another common vegetation type on the base, is reviewed by Mooney (1977), and was later studied by Westman (1981, 1982). Each of these vegetation types is also discussed in the Ecological Assessment of Vandenberg by Coulombe and Cooper (1976) and in the recent study by Schmalzer et al. (1988).

The vegetation in the Vandenberg area has been subjected to varying fire regimes throughout history. The prehistoric fire regime is a matter of conjecture. Based on records dating from 1929, lightning is extremely rare, only occasionally striking the area around Tranquillon Peak. Therefore, lightning was probably infrequent before settlement. Lightning is not infrequent elsewhere in the region (e.g., the San Rafael Mountains to the east). The frequency of prehistoric lightning fires initiated elsewhere and spreading into the Vandenberg area is not known. Most prehistoric fires were probably set by aboriginal people. Early explorers and Spanish missionaries left records describing frequent burning by the Chumash Indians of large areas along the coast of what is now Santa Barbara County, presumably to encourage the growth of fire-following species, the seeds of which were eaten (Timbrook et al. 1982). This practice of burning was outlawed in the late 1700's with the establishment of the Spanish Missions. Cattle and sheep grazing, along with the practice of controlled burning for range improvement, had a great impact on the vegetation for the next century.

The recent fire history of Vandenberg has been examined in several studies. In the Wildland Fuel Management Plan, an analysis of the limited fire history that had been documented at the time revealed that: 1) there had been few recent large wildfires; 2) prescribed burning for range improvement was common on South Base in the past; and 3) most wildfires were man-caused (Wakimoto et al. 1980b). Based on ring counts, Coulombe and Cooper (1976) determined the "greater part of chaparral vegetation" on the base to be from 15 to 30 years old. In a study of the Bishop pine forests, Zedler (1977) found even-aged stands (which result from fire) ranging from 15 to 35 years old on South Base. Hickson (1987a) compiled a fire history of Burton Mesa. More specific information on some historic fires is contained in assorted reports, records, and maps held by the Base Historian and Fire Department. However, this information is not comprehensive, nor is it in a format that is easily used.

In this study, the location, fuel type, and causes of past fires on Vandenberg are determined, using the aforementioned information and other sources. The fires are mapped and entered into a geographic information system (GIS) for the base, which can be updated and used by both wildland fuel and land managers. In addition, 1:9600 scale maps of the fires corresponding to Master Planning map sheets and derived from the GIS are presented (Hickson 1987b) and are on deposit with the Vandenberg Environmental Task Force Office.

The presence of *Carpobrotus edulis* in recently burned sites in Burton Mesa chaparral on Vandenberg is a serious concern. This invasive exotic is also a problem in other coastal vegetation types (see review in Schmalzer and Hinkle 1987). The connection between its establishment and fire was noted by Jacks et al. (1984) while studying the response of the rare plant *Eriodictyon capitatum* to a prescribed fire. In a follow-up study, Zedler and Scheid (1987) quantified an increase in *C. edulis* in the three years following the prescribed burn.

This report contains the results of a preliminary study of the invasion of three exotics, including *Carpobrotus edulis*, into Burton Mesa chaparral, and offers recommendations for management and further study.

METHODS

Fire History

The fire history for the past 50 plus years of the area now included within Vandenberg was reconstructed from written records and from black-and-white, color, and color infrared aerial photography (Table 1). The first complete photographic coverage of the base is from 1938. Complete coverage also exists for the years 1954, 1971, 1974, 1978, 1980, 1981, and 1986. Partial coverage exists for sixteen other dates. The most recent imagery was flown by the NASA/Ames High Altitude Aircraft Program for the Air Force in December, 1986.

Information on the fires, such as exact date, fuel type, and cause, was obtained from the following sources: Vandenberg Fire Department Fuel Management Plan yearly records from 1981 to 1986, maps of wildfires and controlled burns from 1977 to present provided by the Fire Department, an historical report of major brush fires from 1957 to 1982 provided by the Base Historian, editions of the local newspaper (*The Lompoc Record*) from the years 1931 to 1956, and interviews with Vandenberg and Santa Barbara County Fire Department personnel and long-time residents of Lompoc. A large prescribed burn in 1977 is described in a report by Perry and Simmons (1977). Some burn sites were first discovered in the field while ground-truthing for vegetation age-classes. The most recent fire mapped occurred on August 19, 1987. Some controlled burns on Burton Mesa and a wildfire near LF-09 occurred in the fall of 1987, after mapping was completed.

Table 1. Aerial photography used for fire history.

Year	Date	Coverage[1]	Scale	Flight Number[2]
1928	—	P	1:12,000	C-307 A,B,C, C-311D
1938	Jan	C	1:40,000	C-5140
1943	21 Sep	P	1:20,000	BTM 1944
1954	20 Feb	C	1:20,000	BTM 1954
1956	22 Apr	P	1:11,400	HA-AN
1958	13 Dec	P	1:4,300	HA-DS
1960	17 Oct	P	1:19,000	HA-JT
1966	22 Jun	P	1:22,600	HB-HU
1967	14 May	P	1:20,000	BTM 1967
1968	5 Jan	P	1:12,000	HB-LH
1969	26 Jan	P	1:6,000	HB-NN
1969	25 Feb	P	1:12,000	HB-OL
1971	2 Apr	C	1:120,000	NASA/MSC 164 site 254, flt. 5, roll 29 (CIR)
1972	13 Dec	P	1:11,000	NASA/MSC 224 site 254, flt. 2, roll 12 (CIR)
1972	20 Nov	C	1:80,000	HB-UR
1973	23 May	P	1:36,000	NASA/MSC 235 site 254, flt. 4, roll 17 (CIR)
1974	20 May	C	1:14,000	AF74-9
1975	Dec	P	1:36,000	AMI SB 75
1978	20 Sep	C	1:40,000	USDA-40-06083
1980	19 Oct	C	1:40,000	USDA-FIRESCOPE roll 11 (CIR)
1981	17 Jun	C	1:40,000	USDA-FIRESCOPE roll 14 (CIR)
1981	19 Oct	C	1:58,000	NHAP 81 (CIR)
1983	29 Mar	P	1:24,000	PW-15188 (color)
1986	29 Apr	P	Variable	USAF imagery (color and CIR) of SLC-4 and SLC-6
1986	6 Dec	C	1:30,000	Access 03613, 87-040 (B/W, color, and CIR)

[1]C=Complete, P=Partial coverage

[2]All imagery is B/W print or negative, except where noted, and is in the University of California, Santa Barbara Map and Imagery Laboratory collection. Exceptions: the 1928 photos, which are at Whittier College, Whittier, California; the 1983 photos, which are available from Pacific Western Aerial Surveys, Santa Barbara, California; and the 1986 imagery, held by the U.S. Air Force.

Burned areas in dense chaparral in the Vandenberg area can be detected on aerial photography taken up to ten years after the fire (Hickson 1987a). There is a continuous fire record for this vegetation for the periods 1928 to 1938, 1944 to 1954, and 1961 to the present, and partial coverage of much of the base at intermediate dates.

Other vegetation types may display only subtle texture or color differences between the burned and adjacent unburned vegetation on aerial photography taken even a short time after the fire. The location of burn boundaries in these cases was facilitated by *a priori* knowledge of the fire obtained from the sources listed above, including the size, location, fuel type, direction of burn, and location of fuel breaks.

Evidence of burning in annual grassland is not visible on aerial photography or in the field beyond the first growing season after fire; thus, fires in grassland could not be located except when there was fortuitous aerial photography coverage or when an informant could identify the exact fire boundaries. Beyond the first year after fire, the fuel class for grassland does not change. Thus, mapping historical fires that occurred in this vegetation type would not be useful for fuel management purposes.

In interviews with Fire Department personnel, the minimum fuel management size was given as 8.1 ha (20 ac). Fires smaller than this were not included in the fire history unless they were controlled burns or were located in heavy fuel near facilities.

Mapping and Digitization of Fires

Burned areas on the aerial photography were located and mapped onto Vandenberg Master Planning (MP) maps (nominally 1:9600 scale) using a Bausch and Lomb Zoom Transfer Scope. Dates were then assigned to the mapped fires based on the written records mentioned above and/or interviews. Where no written or oral record existed of a fire located on photographs, the date was bracketed by the aerial photography coverage dates and the year of the fire was estimated.

The burn sites were field checked for exact boundary locations and unburned islands of vegetation using the MP maps and the 1986 aerial photography. At chaparral-covered sites that burned less than 15 years previous, the presence of charred stems made the burn boundaries evident.

Fire boundaries were digitized using the ERDAS (Earth Resource Data Analysis System) software programs DIGPOL and DIGBND. Since the scale varied among MP maps, the scale of each map was calculated based on at least three measurements. ERDAS allows a test of the accuracy of the map set-up prior to digitization; the scale that yielded the most accurate test was used. The digitized information was then converted to raster (grid) format using the program GRDPOL at a spatial resolution of 30 m (98.425 ft), thereby creating a fire history data "layer" for the GIS.

The ERDAS program GISMAP was used to produce fire history maps corresponding to individual MP map sheets at 1:9600 scale (Hickson 1987b). These maps were derived from the rasterized, composite database. Fires on the maps were color-coded by year and type (wildfire or controlled burn).

Sampling for Exotics

To obtain a quantitative indication of the invasion of burned areas by three exotic weeds, 60 m transects were randomly located in 12 burned and 4 unburned areas on Burton Mesa (Table 2) using a compass and a random number table to determine random starting positions and compass bearings for the transects. The presence of *Carpobrotus edulis, Conicosia pugioniformis,*

Table 2. Description of sites in the exotic species study and frequencies (percent of quadrats in which species were found) of exotics in transects.

Site	Year burned	MP map number	Number of quadrats	Frequency *Carpobrotus edulis*	Frequency *Conicosia pugioniformis*	Frequency *Cortaderia jubata*
1	1984	33	52	54	0	0
2	crushed	33	26	38	19	0
3	—	33	39	0	0	0
4	crushed	33	39	0	0	5
5	—	33	39	41	0	10
6	—	28	39	0	0	3
7	—	28	39	0	0	0
8	ca. 1980	37	52	11	25	0
9	1981	30,35	42	28	0	0
10	1981	38	56	39	0	0
11	1985	38	41	37	0	0
12	1982	37	39	49	0	0
13	ca. 1952	38	—	None of these exotics observed		
14	ca. 1940	29	—	None of these exotics observed		
15	1986	28,33	—	*Carpobrotus, Conicosia* seedlings		
16	1986	29	—	*Carpobrotus* seedlings		
17	1986	42	—	*Carpobrotus, Conicosia* seedlings		
18	ca. 1960	29	—	None of these exotics observed		

and *Cortaderia jubata* in a 1 m^2 quadrat placed along the tape at 5 m intervals was recorded. One to four transects were laid out in each burned area, depending upon the size of the burn and the variation in vegetation present. Transects were located in unburned areas adjacent to the first burn sites sampled, but the frequency of exotics was soon found to be nil in the unburned chaparral, and the sampling was time consuming and difficult. Thereafter the boundary of the burned area was walked and a search was made for exotic species in the adjacent unburned chaparral. Two areas that had been crushed but not burned by the Fire Department were also sampled. Sites burned before 1986 were sampled during the first two weeks of February 1987, and sites burned in 1986 in June 1987.

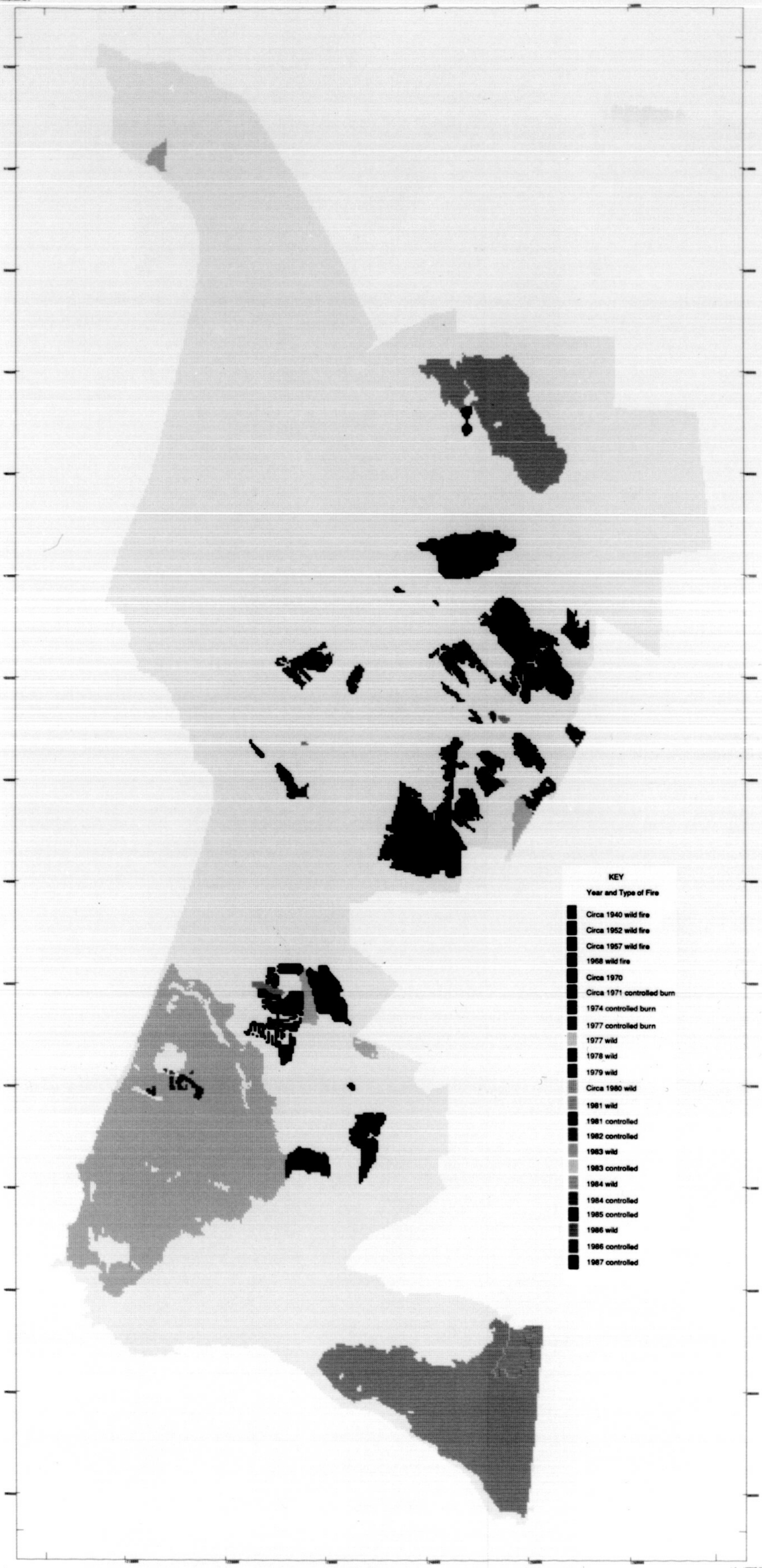
RESULTS

Fire History

Sixty fires were located and mapped (Figure 1); 30 were documented controlled burns (1188.6 ha total), and 13 were documented wildfires (8026.6 ha total). The remaining 17 undocumented fires that occurred prior to 1970 were classified as wildfires in the GIS, since none had the distinct boundaries indicative of controlled burns. The date, MP map sheet number(s), information source, cause, and fuel type for each mapped fire is given in Table 3. A summary of the area burned in each year or year-group is given in Table 4.

The 60 fires comprise the fire history data layer of the GIS. Two types of GIS files are presented: single year (or year-groups) with fires classified either as wildfires or controlled burns (18 files), and a composite file with all mapped fires. The yearly files are useful in displaying fires or determining acreage burned in a given year. The composite file is a record of vegetation age-classes, since areas burned more than once are assigned the date of the most

Figure 1. Map of historic fires, Vandenberg Air Force Base.



Historic Fires
Vandenberg Air Force Base
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Mapping: This map of historic fires on Vandenberg Air Force Base was prepared from recent and historic aerial imagery, historic records, and ground truthing. Base maps were prepared on Master Planning maps and digitized using ERDAS software. This mosaic was extracted from a gridded data base having a pixel resolution of 30 meters. This map was prepared for the Environmental Task Force.

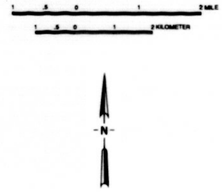

Table 3. Fires documented on fire history maps.

Year	Date	Map[1]	Source[2]	Area (ha)	GIS value	Type and cause[3]
1941	26 Sep	38,42	R	421	5	Wild, construction of main base facilities
ca 1940	—	29	P	14	5	Wild
ca 1940	—	29,30,35	P	162	5	Wild
ca 1940	—	29,34	P	8	5	Wild
ca 1940	—	34	P	7	5	Wild
ca 1952	—	30,35	P	8	6	Wild
ca 1952	—	34	P	10	6	Wild
ca 1952	—	35	P	7	6	Wild
1952	15 Jul	35,39	R	59	6	Wild, discarded cigarette
ca 1952	—	37	P	29	6	Wild
ca 1952	—	38	P	4	6	Wild
ca 1952	—	38,42	P	66	6	Wild
ca 1957	—	34,38,42	P	103	7	Wild
ca 1957	—	38	P	4	7	Wild
ca 1957	—	29,30,34,35	P	374	7	Wild
ca 1957	—	29,34	P	76	7	Wild
ca 1957	—	34	P	8	7	Wild
1968	21 Jul	24,25,29	I	262	8	Wild, unknown origin
ca 1970	—	37	P	5	9	Wild
ca 1971	—	47,48,50	P	157	10	Controlled
1974	—	51	P	4	11	Controlled
1977	Jul	29,30,35	I	88	12	Controlled
1977	20,21 Dec	46,47,49,50,53 54,57,58	I	3334	13	Wild, downed power line
1978	24 Sep	51,55	I	111	14	Wild, no cause information
1979	3 Jul	30	I	58	15	Wild, escaped controlled burn
ca 1980	—	37	P	2	16	Wild
1981	15 Jul	62,63,64,65,66	F	1883	17	Wild, no cause information
1981	13 Aug, 16 Nov 2-3 Dec	38	I	30	18	Controlled
1981	19 Sep	34	I	6	17	Wild, unknown origin
1981	6 Oct	44,45,47,48	F	22	18	Controlled
1981	13 Oct	29	F	4	18	Controlled
1981	15 Oct	29	F	1	18	Controlled
1981	19 Oct	14,19	F	19	18	Controlled

Table 3. (continued).

Year	Date	Map[1]	Source[2]	Area (ha)	GIS value	Type and cause[3]
1981	27 Oct	33	F	10	18	Controlled
1981	9 Nov	30,35	I	16	18	Controlled
1982	13 Jul	34	I	6	19	Controlled
1982	4,5,23,26 Aug	39	I	43	19	Controlled
1982	24-25 Aug	37	F	14	19	Controlled
1982	27,30 Aug, 2 Sep	54,55	I	91	19	Controlled
1982	14 Oct	35,39	I	20	19	Controlled
1983	26 Jul	5,7	F	39	21	Controlled
1983	16 Aug	48,51	F	26	21	Controlled
1983	10 Sep	47	F/I	22	20	Wild, unknown origin
1983	29 Sep	57,60	I	90	21	Controlled
1983	18 Oct	38,39	F/I	4	21	Controlled
1983	19,20 Oct	48	F	57	21	Controlled
1983	9 Nov	39,43	I	52	21	Controlled
1984	7 May	14,15,19,20	F	801	22	Wild, discarded cigarette
1984	15 Aug	33	F	16	23	Controlled
1984	30,31 Aug	63,65	I	105	22	Wild, unknown origin
1985	10 Aug	38	I	40	24	Controlled
1986	18 Apr	49,50	F	37	25	Wild, Titan launch explosion
1986	14 Jul	42	F	77	26	Controlled
1986	22 Jul	28,33	F	98	26	Controlled and wild, escaped controlled burn
1986	1 Nov	29	I	2	25	Wild, unknown origin
1987	13 May	24	G/I	12	27	Controlled
1987	6 Jul	47,50	G/I	13	27	Controlled
1987	20 Jul	47,48	G/I	38	27	Controlled
1987	19 Aug	48	G/I	140	27	Controlled

1 Numbers of Master Planning Maps on which fire is located.

2 F=Fire Department fire reports.
G=Ground truth only, no photographic coverage available.
I=Interviews with Fire Department personnel.
P=Fire located on photos only, age is bracketed with coverage of two dates or estimated.
R=Lompoc *Record*.

3 All fires with no documentation other than photos are considered wildfires.

Table 4. Area burned by mapped fires.

Year	type[1]	Fire in given year (ha)	Area burned in year but not burned by subsequent fire(s) (ha)
ca. 1940	W	612.3	361.6
ca. 1952	W	183.3	160.2
ca. 1957	W	563.0	422.3
1968	W	261.7	249.0
ca. 1970	W	5.5	5.5
ca. 1971	C	156.9	119.2
1974	C	3.6	3.6
1977	C	88.8	88.8
1977	W	3334.0	3295.7
1978	W	110.6	110.6
1979	W	57.7	57.7
ca. 1980	W	2.2	2.2
1981	W	1889.7	1786.4
1981	C	103.0	102.0
1982	C	174.9	172.8
1983	W	21.8	21.8
1983	C	268.6	267.2
1984	W	905.6	905.6
1984	C	15.6	15.6
1985	C	39.7	39.7
1986	W	39.5	39.5
1986	C	174.7	174.7
1987	C	202.5	202.5

[1]W=wildfire
C=controlled burn

recent fire. The codes used in the composite file are given in Table 3. GIS filenames and descriptions are in Appendix 1.

Maps of the 38 MP sheets in which fires occurred (Hickson 1987b), and the blueprint maps from which the fires were digitized are on deposit with the Vandenberg Environmental Task Force Office.

Forty-two 8.1 plus ha (20 plus ac) wildland fires that were not mapped are listed in Table 5. These fires could not be mapped for one or more of the following reasons: 1) the vegetation type was primarily grassland and therefore the burned area was not discernable on aerial photography taken more than one season after the fire; 2) there was no recent aerial photography coverage of the burned area; or 3) there was insufficient information about the location of the fire.

Exotic Species Study

All of the sites sampled that burned between 1980 and 1985 contained *Carpobrotus edulis*, at frequencies varying from 11 to 54 percent (Table 2). The older stands of chaparral (burned in approximately 1940, 1952, and 1960) contained no *Carpobrotus*, although one control (unburned) site contained this species in 41 percent of the quadrats. At all burned sites sampled, no *Carpobrotus* was observed in the adjacent unburned chaparral. One of the sites that had been crushed with a "sheep's foot roller" contained *Carpobrotus* in 38 percent of the quadrats.

The presence of *Conicosia pugioniformis* and *Cortaderia jubata* was not strongly related to the occurrence of fire. Observations suggest that *Conicosia* occurs primarily in mechanically disturbed or eroded soils such as along fuel breaks and jeep trails. This species was observed in 19 percent of the quadrats at one of the crushed, but unburned, sites. Prevalence of *Conicosia* in

Table 5. Fires not documented on fire history maps.

Year	Date	Source[1]	Location	Acres	Notes (fuel type, cause)
1931	23 Jul	R	Jesus Maria Ranch on Burton Mesa	75	Mostly brush, probably caused by cigarette.
1933	15 Aug	R	Jesus Maria Ranch	—	Range, unexplained origin
1934	17 Sep	R	Sudden Ranch	200	Range, possibly started by deer hunter
1936	28 Aug	R	Head of Bear Creek to Lompoc Canyon	800	No fuel or cause given
1936	1 Dec	R	Bear Creek District, Milani ranch	200	Brush, escaped controlled burn
1937	10 Dec	R	Between Casmalia and Pt. Sal	300	Brush, incendiary origin
1940	16 Aug	R	Santa Lucia Canyon near jct of Pine Canyon Road	200	Brush, no cause given
1940	12 Dec	R	Lompoc Canyon to Bear Creek	>1000	Brush, incendiary origin
1940	12 Dec	R	Sloans Canyon to La Salle Canyon	>1700	Brush, ranch owner started fire
1943	12 Dec	R	Stewart Canyon, Lompoc Canyon to east of Honda Canyon	1500	Brush, no cause given
1944	26 Jun	R	Honda Creek Road	—	Brush, caused by tracer bullets
1945	7 Sep	R	Between Casmalia and Pt. Sal	—	Sparks from train
1946	28 Nov	R	Intersection of Camp Cooke Rd. and Orcutt Road	—	Brush, arson
1948	13 Jan	R	Camp Cooke	300	Brush, no cause given
1950	9 Feb	R	Camp Cooke near Casmalia	20	Brush, arson
1953	14 Dec	R	Bear Creek, Camp Cooke	50-100	Range, cause undetermined
1954	1 Dec	R	Camp Cooke to Casmalia from Marshallia Ranch	3000	Brush and grass, escape from controlled burn at Marshallia Ranch in San Antonio area
1957	4 Jul	R	Sudden Ranch near Arlight	20	Grass fire, sparks from train
1958	23 Oct	R	Perimeter of VAFB	6000	Controlled burn for fuelbreak
1958	13 Nov	R	South slope of Tranquillon Peak	800	Brush, possibly lightning
1959	14 May	R	Sudden Ranch	240	Grass, train hot box
1961	3 Jul	R	Sudden Ranch near Pt. Arguello	38	Grass, sparks from train
1963	17 Jul	R	VAFB	23	2 brush fires, no other information
1964	16 Jul	R	Several hundred meters north of main gate, VAFB	100	Brush, no cause given
1964	7 Jul	H	LF-02	100	Brush, inflight destruction of missile
1965	27 Oct	H	Base picnic area	25	Brush, no cause information
1966	11 Jul	H	LF-03	315	Brush, inflight destruction of missile
1966	13 Jul	H	LF-02	45	Brush, inflight destruction of missile
1967	18 Aug	H	1.6 km east of base sewage plant	40	Brush, no cause information
1968	10 Sep	H	East of Pine Canyon gate	10-25	Brush, no cause given
1975	13 Aug	H	3.2 km north of base rifle range	30	No cause or fuel information
1976	27 Feb	H	LF-03	200	Grass and brush, missile launch
1976	23 Jun	H	LF-05	—	Numerous small brush fires, missile launch
1976	24 Jun	H	Base picnic grounds	900	Grass and brush, cause unknown, possibly reburned in 1984
1981	21 Aug	F	Del Punta Road	22	Grass, controlled burn
1982	20,22,27 Jul	F	Pt. Sal, PS-B[2]	218	Coastal sage scrub, grass, controlled burn
1982	14 Sep	F	Manzanita Road, SG-A[2]	30	Controlled burn, less than 20% burned

Table 5. (continued).

Year	Date	Source[1]	Location	Acres	Notes (fuel type, cause)
1982	29 Sep	F	Boat house	45	Grass, downed power line
1984	15 May	F	ORV area	50	Grass and coastal sage scrub, controlled burn
1985	15 May	F	ORV area	50	Same burn as 1984?
1985	15 Jul	F	S-20 "Barka fire"	50	Grass, cause unknown
1985	21 Aug 3	F	SLC-4	30	Brush, missile launch

[1] R=Lompoc *Record*
H=Base Historical records
F=Fire Department records, Fuel Management Plan reports
[2] Fuel management plan identifying code

disturbed soils has also been observed and quantified along the route of a subterranean oil pipeline recently installed on the Burton Mesa (Carla D'Antonio, pers. comm.). *Cortaderia* is also found in disturbed areas, and was found in gaps in the chaparral that showed no evidence of disturbance.

DISCUSSION

Fire History

The first purpose for compiling this fire history was to provide information on location of past wildland fires for use in fuel management. The exact locations of many historic fires are presented on maps and in GIS files produced in this project (maps and GIS files on deposit with Vandenberg Environmental Task Force Office). Since no exact methods of age-classing (e.g., coring) were used in this study, determination of age-classes in areas that did not have documented fires could not be made. However, all burned areas that were evident in the field were dated, and most large brush fires since 1957 are well-documented; therefore, it is reasonable to assign these "non-burned" areas a minimum age since fire of 30 years. Some other generalizations can be drawn about the age-classes of vegetation and the pattern of fires on the base. Based on aerial photography, most of Burton Mesa west of Highway 1 and most of the Lompoc Terrace were cultivated at least until 1938. Therefore, the chaparral in these areas is no more than 50 years old. Much of the brush on the northern slopes of the Santa Ynez mountains was probably burned in the four large fires that occurred there in the early 1940's and in 1953 (Table 5). These dates correspond to Bishop pine stand ages in this area (Zedler 1977).

Much of the chaparral in the roughest terrain, the slopes of Honda Canyon and nearby canyons, was last burned in the 1977 wildfire on South Base. Some of the remaining chaparral in this area has been controlled-burned since then. However, large areas of coastal sage scrub in the Santa Ynez Mountains, between the areas burned by the 1981 wildfire on Oak Mountain and the 1977 wildfire, have probably not burned in at least 40 years.

Controlled burning since 1981 has been concentrated in three areas: in grassland (for range improvement), in areas around base housing and the picnic area (for safety purposes), and in areas of Burton Mesa chaparral and its related form on the Lompoc Terrace of South Base (for fuel reduction and wildlife habitat improvement).

The fire history GIS data layer, when combined with the vegetation data layer (Provancha 1988), can be used to determine the areas on base with the highest fuel loadings that potentially should receive priority under the Fuel Management Plan. If kept up to date, the data base can be used in the event of a wildfire to determine the amount of fuel likely to be encountered by the spreading fire and the location of possible fuel discontinuities created by young vegetation. The GIS format is also an efficient way of recording fires so that the information can be combined with other environmental data.

The second purpose for compiling a fire history is to provide insight into how past fires have affected vegetation patterns as a basis for further study to provide ecologically sound methods of burning. In addition, the results of this study can be used to locate vegetation stands of various ages, or to determine the fire history of a particular site.

In order to manage for optimum regeneration and maintenance of plant communities, knowledge of the natural fire return interval and responses of the plant communities to fire is required. Existing information does not provide enough evidence to establish a "natural" fire frequency.

Aspects of the fire regime in addition to return interval may also affect the regeneration of vegetation following fire. Parker (1987) suggests that controlled burning, which usually occurs under cooler and moister conditions than would normally occur during the "natural" fire season, may affect regrowth in at least two ways: burning when soil moisture is high increases the mortality of seeds in the soil, and burning in the spring, when the resources of burl-sprouting shrubs are allocated to above-ground growth, may kill species such as *Adenostoma fasciculatum*, if they do not have adequate below-ground energy reserves to resprout. Short intervals between fires may change species composition drastically (Zedler et al. 1983). Size of the area burned may also influence fire response, since small burns may be subject to abnormal amounts of herbivory.

Ideally, natural fire regimes should be adapted to the vegetation of Vandenberg. Unfortunately, natural fire frequencies are not well known for the vegetation types that occur on Vandenberg. Some studies have suggested that the fire return interval in coastal regions is fairly long, possibly over 100 years (Wells 1962, Keeley and Keeley 1986). Westman (1982) suggested a 20 year interval for coastal sage scrub although he observed healthy stands that had not burned in at least 60 years. Zedler (1977) found that young stands of Bishop pine had sufficient cone crops to allow burning on a rotation of 25 years; however, he considered that conclusion tentative, since the sample size was not large. Further research would be needed to determine the optimum fire frequency for these vegetation types.

It is likely that the natural fire interval for Burton Mesa chaparral, an especially important vegetation type because of the number of endemic species it contains, is quite long, since the mesa is at low elevation (average 90 m), and the few lightning strikes recorded in the region have been in the distant mountains. Species composition of Burton Mesa chaparral is related to time since fire, along with depth to a subsoil pan and distance from the coast, with greater cover of the dominants *Arctostaphylos rudis* and *Arctostaphylos* *purissima* found in older sites (Hickson 1987a, Davis et al. 1987). Burton Mesa chaparral may have once covered approximately 9000 ha, based on an analysis of topography and substrate. Aerial photography shows that in 1938, 5900 ha were left, and at present, 3500 ha. Sixty-six percent of the remaining Burton Mesa chaparral is within Vandenberg, much of it in a fragmented and degraded state. The dense population and development on the mesa has necessitated intensive controlled burning of the chaparral and has contributed to the occurrence of many wildfires.

Longer fire intervals appear to favor the increased cover of coast live oak (*Quercus agrifolia*) that occurs scattered within Burton Mesa chaparral (Wells 1962, Hickson 1987a).

Exotics

The observations made in this study, along with those made by Zedler and Scheid (1987), suggest that burning of Burton Mesa chaparral may encourage the invasion of *Carpobrotus edulis*. This plant is found in every area on the mesa west of Santa Lucia Canyon that has burned since 1981. *Carpobrotus* does not occur in the 20- to 40-year-old sites possibly because: 1) it had not spread to those areas of the base by the time the fires occurred, and therefore there was no local seed source; or 2) *Carpobrotus* invaded the burn sites but has since been replaced by chaparral species.

Carpobrotus edulis is animal-dispersed; germination is greatly enhanced by passing through the guts of rabbits (Carla D'Antonio, pers. comm.) and possibly other small mammals. This exotic plant is now distributed on Vandenberg along roadsides, trails, and utility/communication lines, providing a seed source near all remaining areas of pure (uninvaded) chaparral.

The other two exotics that were included in the sampling, *Cortaderia jubata* and *Conicosia pugioniformis*, are associated with mechanical soil disturbance.

RECOMMENDATIONS FOR MANAGEMENT AND FURTHER STUDY

There is no doubt that wildland fuel management is required on Vandenberg. Aside from the benefits of reduced fuel, burning also creates a more favorable habitat for wildlife and favors the continued existence of fire-adapted plant species. However, certain management and research recommendations must be made based on the current research.

In the environmental assessment of their Fuel Management Plan, Wakimoto et al. (1980a) stressed the use of existing roads, fuel breaks, and natural barriers as fire breaks for controlled burning rather than the creation of new breaks, thus reducing the potential for soil erosion and disturbance of ecosystems. Observations made in the field during this study indicate that mechanical soil disturbance results in the invasion of weedy exotic plants. To keep the plant communities on Vandenberg as natural as possible, it is recommended that new fuel breaks not be established for controlled burning. In addition, the use of existing breaks should be stressed in fighting wildfires. Crushing the chaparral prior to controlled burning, which disturbs the soil, should be avoided.

Although the "natural" fire return intervals for areas within Vandenberg are not known, they are almost certainly much longer than the 20 to 30 year interval now predominant over much of the base as a result of controlled burning and human-caused wildfires. For this reason, some areas of pristine vegetation should be protected from fire. These areas should be chosen based on the following: 1) the absence of weedy exotics; 2) location away from facilities or residences; and 3) low probability of future development. These areas should not be protected from burning at all costs, but should not be scheduled for controlled burning. This would ensure that some areas are maintained in mature condition, providing areas that can be compared to burned sites, and would maintain populations of species that may require or be favored by long fire intervals. Substantial areas of Burton Mesa chaparral, in particular, should be protected from fire, or burned very infrequently. In addition, the areas of chaparral included in the controlled burn program should not be burned at the same interval, allowing variation in ages.

Further research is needed on the fire ecology of Burton Mesa chaparral, with the goal of determining, if possible, the optimal fire regime needed to maintain the health of this unique vegetation while reducing the fuel hazard it poses to an acceptable level. The prescribed burning measures (i.e., timing, intensity, and burn size) that minimize the invasion of unwanted exotic plants into chaparral need to be determined. More information is needed to determine if controlled burning does indeed favor the invasion of exotics, and if regeneration of native species is slowed or precluded to any extent by these exotics. In the meantime, controlled burning should be limited to areas where there is no significant seed source of *Carpobrotus edulis* nearby, or eradication of this exotic (see Schmalzer and Hinkle 1987) should precede prescribed burning. The eradication method used should not damage critical native seed assemblages, nor cause excessive soil disturbance.

Because of the significance of Burton Mesa chaparral, an inventory of the seed assemblages in areas of different age-classes should be made. Currently, knowledge of seed bank dynamics in chaparral is lacking. An understanding of inputs, longevity, and losses of seeds during the fire cycle will allow management favoring certain species (e.g. *Ceanothus impressus* var.

impressus, which is found almost exclusively in "young" chaparral) or for vegetation composition or diversity criteria.

Little is known about wildlife responses to the controlled burning program including those of special interest species such as the California legless lizard. Research is needed in this area.

Zedler (1977) stated that active management of Bishop pine forest was unnecessary; however, the pine stands should be examined periodically to detect any decline in overall health. Since it has been 10 years since Zedler's study, these stands should soon be examined again and subsequently at regular intervals not exceeding 10 years. No controlled burns are scheduled in areas containing Bishop pine forest in the near future (Tony Rabonza, pers. comm.), allowing time to monitor the condition of these stands. As recommended by Zedler (1977), any controlled burn in Bishop pine forest should be a high intensity fire. This ensures the opening of a maximum number of cones and the death of the old trees, conditions necessary for vigorous regeneration.

Controlled burning for fuel management is necessary on Vandenberg, given the favorable conditions for large wildfires. Currently, however, there is no formal schedule for burning or recommendations for fire intervals for individual shrub communities on Vandenberg. Further study is needed so that ecologically sound, community-specific fuel management plans can be developed.

One strategy that should be considered would be to manage by controlled burning the vegetation and fuel loads in the vicinity of structures and facilities where they represent a fire hazard and to do little or no burning in areas remote from facilities. The vegetation and fire history layers of the GIS can be used to determine vegetation types and age classes within a given distance of facilities. With additional research, it might be possible to link models of fire spread and behavior to the GIS data base providing a predictive tool for both controlled burns and wildfires.

To maintain the utility of the fire history "layer" of the GIS, all new fires should be mapped accurately, digitized, and added to the existing data base on a periodic basis. Although historic small fires and grassland fires are not included in the data base thus far; all future fires can be easily added. This will improve the utility of the data base.

CONCLUSIONS

1) Most of the hazardous wildland fuel on Vandenberg is in the 10- to 50-year age-class. Age-classes can be determined from the fire history maps (Hickson 1987b) and GIS files produced in this project (maps and GIS files on deposit with Vandenberg Environmental Task Force Office).

2) The Wildland Fuel Management program has burned 939.3 ha since it was implemented in 1981. In the same period, wildfires have burned 2896.3 ha.

3) The modern fire regime is completely anthropogenic. Only one of the 102 mapped and unmapped fires of more than 8.1 ha in size was even possibly lightning-caused. This study, limited to the past 50 plus years, uncovered no evidence from which to determine a "natural" fire frequency. However, since much of the vegetation on Vandenberg is fire-dependent, further study is needed to determine type-specific fire frequencies that both reduce wildland fuel and ensure optimum regeneration and maintenance of the unique vegetation and habitats on Vandenberg.

4) There is evidence that burning some plant communities encourages the invasion of weedy exotic species that may not be replaced by the regrowth

of native vegetation after fire. This is especially significant for the management of Burton Mesa chaparral; 65 percent of the remaining 3489 ha of this community is on Vandenberg, and only a fraction of the Burton Mesa chaparral off the base is in natural preserves.

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Appendix 1. Fire History GIS Filenames and Descriptions

Filename	Description
Fires.gis	All fire-years overlain, see Table 3 for fire codes.

Following are the yearly fire files.

Codes:
1 = Within VAFB boundary
2 = Controlled burn
3 = Wild fire

1940ca.gis
1952ca.gis
1957ca.gis
1968.gis
1970ca.gis
1971ca.gis
1974.gis
1977.gis
1978.gis
1979.gis
1980ca.gis
1981.gis
1982.gis
1983.gis
1984.gis
1985.gis
1986.gis
1987.gis

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16. Abstract

The fire history of the past 50 years for Vandenberg Air Force Base, California was determined using aerial photography, field investigation, and historical and current written records. This constitutes a record of the vegetation age-classes for the entire base. The location, cause, and fuel type for sixty fires from this time period were determined. The fires were mapped and entered into a geographic information system (GIS) for Vandenberg. Fire history maps derived from this GIS were printed at 1:9600 scale and are on deposit at the Vandenberg Environmental Task Force Office.

Although some ecologically significant plant communities on Vandenberg are adapted to fire, no "natural" fire frequency could be determined, since only one fire possibly caused by lightning occurred in the area now within the base since 1937. Observations made during this study suggest that burning may encourage the invasion of exotic species into chaparral, in particular Burton Mesa or "sandhill" chaparral, an unusual and geographically limited form of chaparral found on the base.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Burton Mesa, California, chaparral, exotic plants, fire history, GIS, mapping, Vandenberg, vegetation	Unlimited National Technical Information Service Subject Category 51

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