DEPARTMENT OF THE NAVY

FINAL
ENVIRONMENTAL IMPACT STATEMENT

KAHOOLAWE ISLAND TARGET COMPLEX

HAWAIIAN ARCHIPELAGO

FEBRUARY 1972

FINAL ENVIRONMENTAL STATEMENT

CONCERNING

MILITARY USE

OF THE

KAHOOLAWE ISLAND TARGET COMPLEX

IN THE

HAWAIIAN ARCHIPELAGO

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OCTOBER 1971

1. Name of Action. Administrative.

2. Description of Action. Kahoolawe, one of the eight main islands in the Hawaiian Archipelago and located about seven miles southwest of Maui, is proposed for continued use as a naval target complex. Approximately 7750 acres, centrally located and comprising one fourth of the Island, is used for training in air-to-ground weapons delivery and shore bombardment, using both live and inert ordnance. The central location affords a measure of safety, allows maximum noise abatement, and is considered to be the part of the Island least environmentally affected by ordnance use.

3. Summary of Environmental Impact and Adverse Environmental Effects. The environmental impact consists of explosions and fragmentation of metal shell and bomb casings on very infertile soil. The adverse effects are cratering, comouflets, sprays of shell and bomb fragments, ground disruption, water pollution, air pollution, destruction of vegetation and animal life, and other related effects in varying degrees confined to the target area and not extending to the neighboring populated islands.

4. Alternatives Considered. Alternative possibilities include conducting weapons training at San Clemente Island, Kaula Rock, the Pacific Missile Range Facility at Barking Sands, the Schofield Barracks Range Complex, the Makua Valley Impact Area or the Pohakuloa Training Area on Hawaii, as well as construction of artificial floating or non-floating islands and design of a realistic training bomb enabling such exercises to be conducted in areas where live ordnance would be unsafe. If the Island is diverted from its present use, alternative uses considered have included agriculture, grazing, recreation, aquaculture, and construction of a nulcear power plant and desalination plant.

5. List of Agencies from which written comments have been Received.

(1) Environmental Protection Agency
(2) Department of Agriculture
(3) Department of the Interior
(4) Department of Commerce
(5) Advisory Council on Historic Preservation

6. Date Draft and Final EIS Made Available to CEQ and Public

Draft EIS	November	1971
Final EIS	February	1972

Part 2.

PROJECT DESCRIPTION

1. Name. Kahoolawe Island Target Complex.

2. Location. It covers most of the central and southerly portions of Kahoolawe Island which is located at about 156 35' West Longitude and 20 33' North Latitude, southeast of the island of Lanai and southwest of the island of Maui in the Hawaiian Archipelago. The island is uninhabited and of marginal utility.

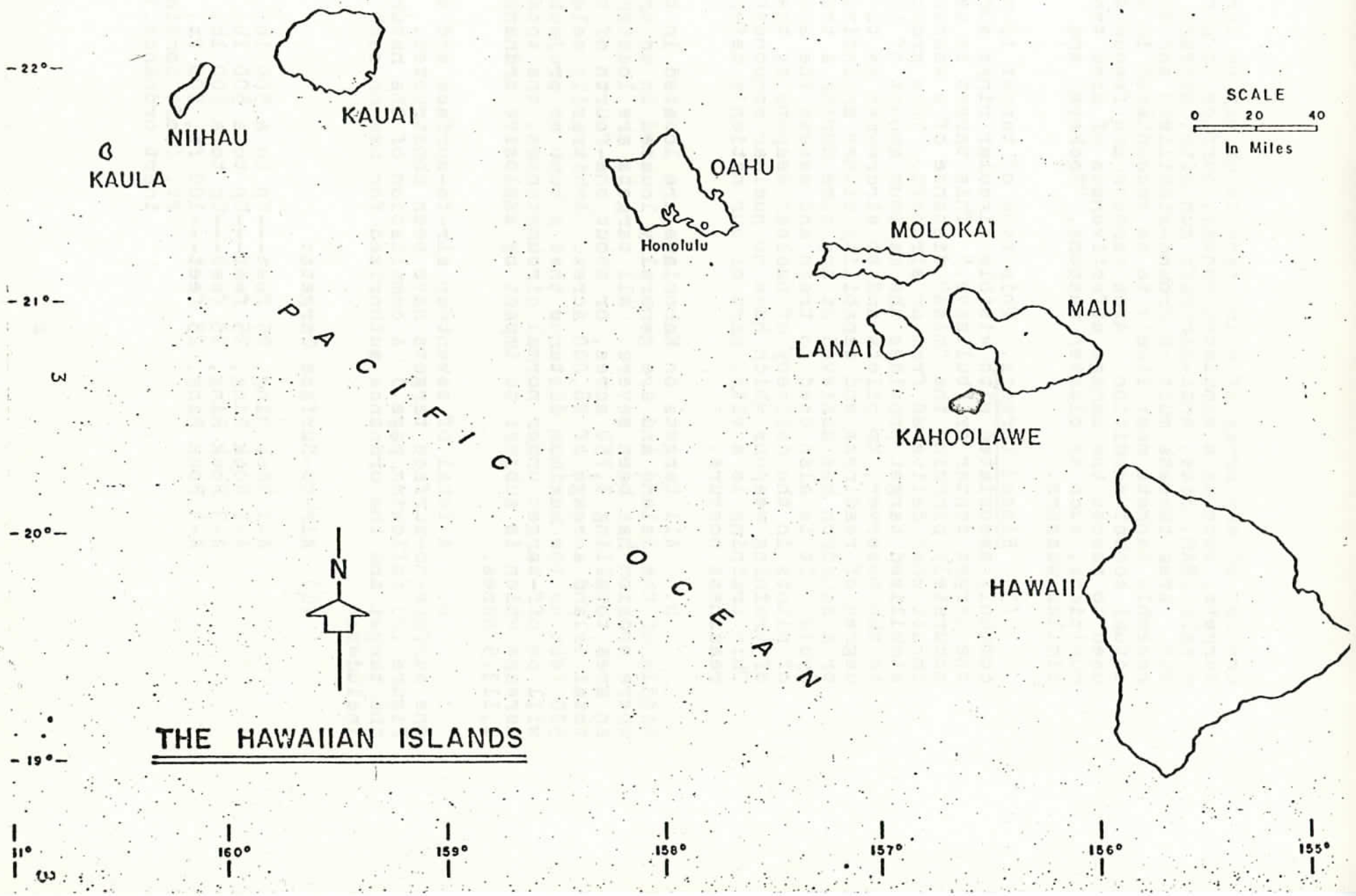
3. Current Military Use.

a. The Kahoolawe Island Target Complex is the outgrowth of development by the Department of the Navy, commenced in 1941, which has been geared to the need for target facilities for aerial and surface bombardment and gunnery exercises to maintain the Navy and Marine Corps' high training and readiness requirements in furtherance of the defense interests of the United States. Through actual combat experience, targets have been designed, built and placed on the island's surface to optimize the island's training environment. These targets are of three basic types and are briefly described as follows:

(1) Point Targets. A point target is a single or small area target needed to assess the accuracy of a pilot, surface ship or weapons system. Point targets must be ground-stabilized, that is, with a known latitude, longitude and elevation. They must possess characteristics of targets likely to be found in actual combat conditions. Point targets are required for use with high explosive conventional ordnance to insure that the entire evolution of handling, loading, fuzing and delivering of ordnance on target is at an acceptable level of readiness and safety. Point targets are also required to assess the effectiveness and delivery accuracy of certain weapons and guns. Strafing targets, NAPALM and "Walleye" targets are examples of these targets. Each has its own material, construction and design features.

(2) Area targets. This type of target is needed to train and test the combat effectiveness of several aircraft or surface ships in the coordinated neutralization of an area using conventional ordnance. Area targets may

FIGURE 1



THE HAWAIIAN ISLANDS

consist of any array of point targets or may be large targets, such as a simulated runway, surface to air missle (SAM) site, anti-aircraft gun site, storage area, etc. Area targets must be ground-stabilized and must resemble targets most likely to be encountered in an actual combat condition. Area targets are frequently used to assess the damage effectiveness of area type munitions, such as cluster weapons, "Rockeye," and similar weapons.

(3) Ringed targets. This type of target is most commonly associated with visible circular rings surrounding the target center or "bullseye." This target is used to accurately pinpoint the "miss" distance of a weapon's impact when delivered from an aircraft. This ground-stabilized target provides the maximum amount of information to the observer, to pilots and to aircrewmen as to the degree of readiness and capability either an individual or a squadron has achieved at any time during a training cycle. It is also used to train and assess the accuracy of pilots in the delivery of nuclear weapons by the use of training weapons which have no nuclear components. This training is a vital part of our nation's defense readiness posture.

b. All targets on Kahoolawe are located in the middle of the island and are generally located in an area where erosion has been severe. All targets are located in an area totalling 7,750 acres, or about one-fourth of the total island acreage of 28,000 acres. Arbitrarily selecting 500 feet as the maximum distance that a bomb or projective will be off-target under normal circumstances, the total acreage which is subject to impact by explosive ordnance is 1,113.5 acres.

c. A total of seventeen air-to-surface and twenty-one surface-to-surface targets have been constructed. (See Figure (2) following page.) A compilation of the nature of the target and the ordnance authorized for use on each target includes:

(1) Air-to-Surface Targets:

A-1 Rock Ring, 25 feet---Up to a 500 lb. bomb;
A-2 Rock Ring, 25 feet---Up to a 500 lb. bomb;
A-3 Rock Ring, 25 feet---Up to a 500 lb. bomb;
A-4 Rock Ring, 25 feet---100 ft, 500 ft, 1000 ft, (Loft bombing target; inert ordnance.);

A-5 West Airfield--------Up to 500 lb. bomb;
A-6 Anti-Aircraft Site---Up to 500 lb. bomb;
A-7 Complex Target, 10'
bull, 40', 100', 200',
300' ring--------------Inert ordnance;
A-8 No. 1 Strafing Target - 20 MM
A-9 No. 2 Strafing Target - 20 MM
A-10 MK-76/2.75 FFARTGT
10' bull, 100', 200', 300' ring (Practice only)
A-11 Rock Ring, 25'------Up to 500 lb. bomb;
A-12 "Walleye" Target----"Walleye";
A-13 ("Z" Convoy) West
Convoy-----------------Up to 500 lb. bomb;
A-14 Central Convoy------Up to 500 lb. bomb;
A-15 East Convoy---------Up to 500 lb. bomb;
A-16 East Airfield-------Up to 500 lb. bomb; and
A-17 Surface-to-Air
Missile Site----------Up to 500 lb. bomb.

(2) Surface-to-Surface Targets:

S-1---------Natural rock target at shoreline;
S-2---------Natural rock target at shoreline;
S-3---------White Cliff target at shoreline;
S-4---------Rock pyramid target 6'x6'x6' high;
S-5---------Barrel pyramid target 7'x7'x11' high;
S-6---------Rock pyramid target 6'x6'x6' high;
S-7---------Rock pyramid target 6'x6'x6' high;
S-8---------Drop tank (night illumination target);
S-9---------Drop tank (night illumination target);
S-10--------Truck target (night illumination target);
S-11--------West end truck convoy;.
S-12--------East end truck convoy;
S-13--------Rock Ring target, 25' (reverse slope
ring target);
S-14--------Rock Ring target, 25' (reverse slope
ring target);
S-15--------Rock Ring target, 10', 25';
S-16--------Truck Target;
S-17--------Truck Target;
S-18--------Rock Pyramid 12'x12'x8' high;
S-19--------500 yd. x 600 yd. targets;
S-20--------Barrel pyramid target; and
S-21--------Friendly Village.

d. During the period from 1 January 1970 to 30 June 1971, Kahoolawe Island was visited 547 times--an approximate average of once every day.

NO.	DESCRIPTION	GRID COORD	
A-1	ROCK RING - 25'	465	716
A-2	ROCK RING - 25'	469	718
A-3	ROCK RING - 25'	481	722
A-4	ROCK RING 100', 500' 1000' (LOFT BOMBING TARGET)	480	719
A-5	WEST AIRFIELD	487	724
A-6	ANTI AIRCRAFT SITE	491	725
A-7	COMPEX TARGET 10' BULL, 40', 100', 200' RINGS	469	729
A-8	81 STRAFING TARGET	472	729
A-9	82 STRAFING TARGET	474	729
A-10	MK-76/275 FEARTGT 10' BULL, 100', 200', 300' RING (PRACTICE ONLY)	475	738
A-11	ROCK RING-25'	483	736
A-12	VALLEYE TARGET	484	737
A-13	("Z" CONVOY) WEST CONVOY	486	727
A-14	CENTRAL CONVOY	490	730
A-15	EAST CONVOY	500	733
A-16	EAST AIRFIELD	508	727
A-17	SAM SITE	504	728
S-1	NATURAL ROCK TARGET AT SHORELINE	465	769
S-2	NATURAL ROCK TARGET AT SHORELINE	467	770
S-3	WHITE CLIFF TARGET AT SHORELINE	466	787
S-4	ROCK PYRAMID TARGET 6'X6' BY 6' HIGH	464	755
S-5	BARREL PYRAMID TARGET 7'X7' BY 11' HIGH	469	761
S-6	ROCK PYRAMID TARGET 6'X6' BY 6' HIGH	482	772
S-7	ROCK PYRAMID TARGET 6'X6' BY 6' HIGH	489	774
S-8	JEEP TARGET	484	742
S-9	DROP TANK (NIGHT ILLUMINATION TARGET)	474	742

NO.	DESCRIPTION	GRID COORD	
S-10	TRUCK TARGET (NIGHT ILLUMINATION TARGET)	476	740
S-11	WEST END TRUCK CONVOY	478	741
S-12	EAST END TRUCK CONVOY	490	750
S-13	ROCK RING TARGET-25' (REVERSE SLOP RING TARGET)	493	755
S-14	ROCK RING TARGET-25' (REVERSE SLOP RING TARGET)	494	757
S-15	ROCK RING TARGET-10', 25'	493	762
S-16	TRUCK TARGET	492	759
S-17	TRUCK TARGET	491	759
S-18	ROCK PYRAMID 12'X12' BY 8' HIGH	494	764
S-19	500YD X 600YD TARGET	495	764
S-20	BARREL PYRAMID TARGET	474	756
S-21	FRIENDLY VILLIGE	529	731

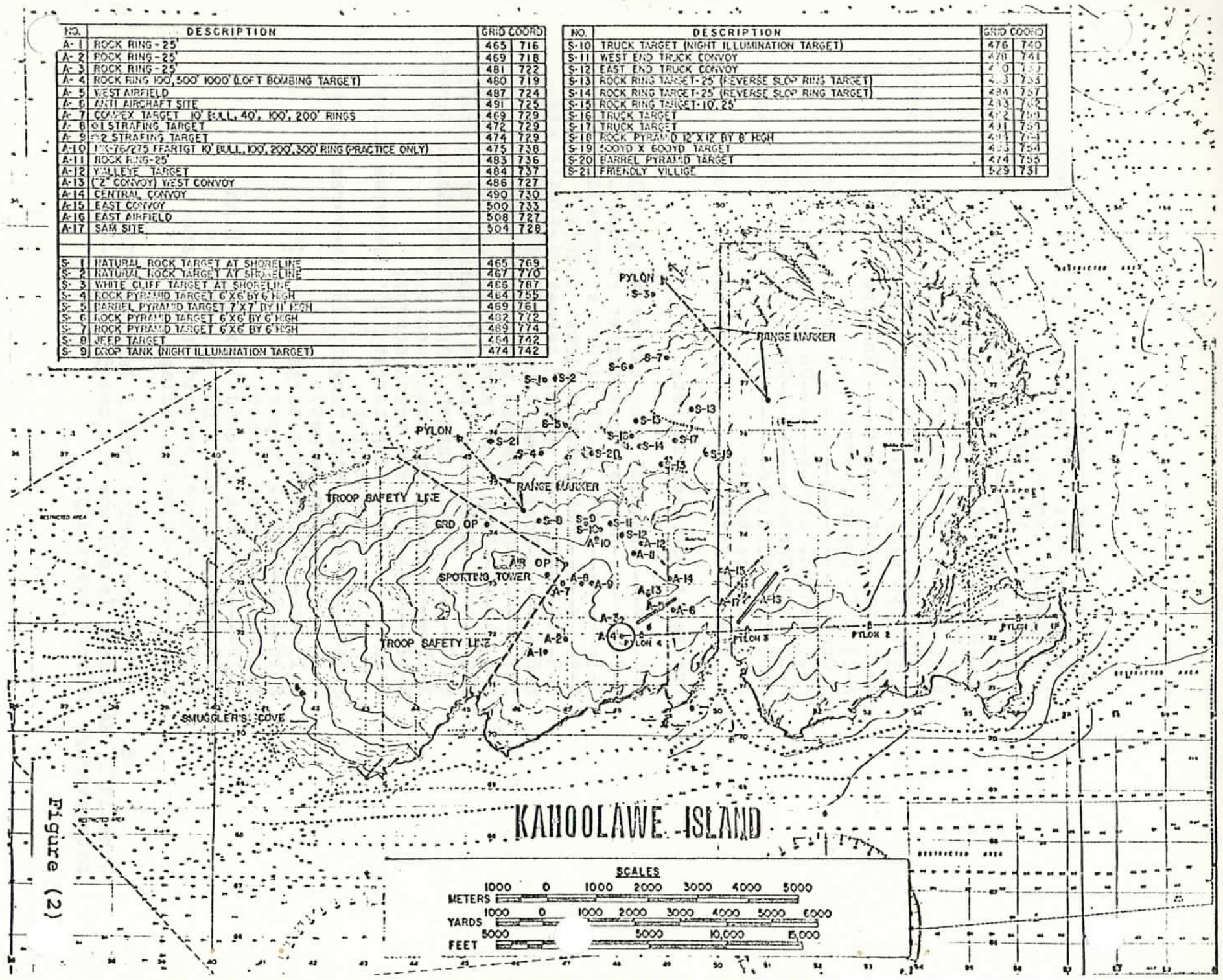


Figure (2)

e. Two hundred twenty five visits were for air-to-ground weapons exercises, fifty-eight visits for shore bombardment from Navy ships and thirty for the purposes of weapons orientation by Navy ships. Maintenance of the target area required two visits for target sanitization, fifty-eight for target survey and two for servicing a light-house.

f. The air-to-ground sorties were flown by U. S. Marine Corps aviators and aircraft from Marine Air Group Twenty-Four, based at Marine Corps Air Station, Kaneohe Bay on Oahu. Other air-to-ground and weapons systems uses were by Naval aviators and aircraft and weapons control systems associated therewith on USS BON HOMME RICHARD (CVA 31), USS RANGER (CVA 61), USS ORISKANY (CVA 34), USS HANCOCK (CVA 19), USS MIDWAY (CVA 41) and USS ENTERPRISE (CVAN 65). Both inert and "live" ordnance was used in these exercises. This naval weapons training was always incident to preparation for deployment of the aircraft by personnel concerned to the theater of operations in the Republic of Vietnam and adjacent waters. Shore bombardment operations were conducted by twenty-eight combatant ships of the U. S. Navy, three U. S. Coast Guard vessels and a combatant ship visiting from the United Kingdom.

g. The yield to the Department of the Navy and the other users of the target complex was an increase in the effectiveness, efficiency and fitness of the personnel, aircraft and weapons systems involved, to the benefit of the defense of our country. Use of the Kahoolawe Island Target Complex at approximately the same levels in the future is anticipated.

4. <u>The Ordnance Used and the Effects of its Explosive Reactions</u>.

a. The largest piece of explosive ordnance authorized for use on the target complex of Kahoolawe is the 500 lb. low drag general purpose bomb, "Mark 82". This bomb has a slender body with a long, tapered nose. A conical fin or a "Snake-eye" fin is attached to the after end of the bomb fuselage, for stability during its flight trajectory. The weight of the bomb is 560 lbs., of which 192 lbs. is the explosive charge.

b. An explosive reaction liberates heat, evolves gases, and develops high pressure.

1. Heat. An explosive reaction is always accompanied by the liberation of heat, which represents the energy of the explosive. This energy is a measure of the explosive's potential for doing work.

2. Gases. The principal gaseous products of commonly used explosives are carbon dioxide (CO_2), carbon monoxide (CO), nitrogen (N_2), hydrogen (H_2), and water (H_2O). Minor products are methane (CH_4), hydrogen cyanide (HCN), and nitrogen oxides (NO_n).

3. Pressure. The high pressure accompanying an explosive reaction is caused by the heating of the gases. In general, maximum pressure of a low explosive is attained comparatively late in the reaction because of the low velocity at which it proceeds. Maximum pressure of a high explosive reaction, however, is attained almost instantly and will be much greater than in the case of a low explosive reaction. This pressure develops so rapidly that any material in contact or nearby is shattered. In particular, the weapon case explodes and breaks into fragments. The air surrounding the casing is compressed and a shock (blast) wave is transmitted into the surrounding air. The energy in the blast wave and the kinetic energy of the fragments account for most of the explosive energy. The fireball gases have appreciable velocity, but the effects of these gases are confined to the immediate vicinity of the burst, whereas the blast wave and fragmentation effects extend a comparatively long distance from the burst.

c. The underground trajectory of a bomb is rarely a straight line. Normally this path is a fairly uniform curve with a concave side toward the ground surface. For angles of impact of sixty degrees or more, measured from the horizontal, the underground trajectory of bombs is such that the final depth below the surface is seventy to ninety per cent of the penetration path length. At angles of impact less than twenty to thirty degrees from the horizontal, the missile may ricochet. Ricochet from the earth is usually accompanied by a furrow along the contact surface or occasionally by a shallow underground hole which returns to the surface. Ricochet depends on many factors such as the density and hardness of the surface, the nose and shape of the projectile, its transverse moment of inertia, as well as the angle of impact. For intermediate angles, the penetration is usually shallow with a large forward onset.

d. When a bomb explodes underground, the expanding gases force back the earth on all sides, forming a cavity. The actual movement of the earth and the ground wave which radiates out on all sides are similar to the outward movement of air in the vicinity of an air explosion and the accompanying blast wave. The two chief differences lie first, in the complex series of reflections caused by the ground wave meeting either the boundaries formed by the earth's surface or changes in the earth's structure and second, in the permanent change of position of large amounts of material because of the relative non-elastic nature of the medium.

e. Should a bomb burst near the surface, most of the crater debris is thrown laterally, forming a clean-swept crater. As the depth of the bomb increases, a progressively larger amount of the crater debris is ejected vertically and falls back into the crater, partly filling it. As the depth of explosion increases, a point is eventually reached where the pressure of the gases is insufficient to eject the earth above and the bomb is said to "camouflet." The underground cavity thus formed, together with the characteristic mound usually formed above it, is known as a "camouflet" or as a partial camouflet if the earth is partially ejected. The gases in a camouflet may force vents to the surface and escape or remain partially confined.

f. Crater dimensions resulting from high explosive bombs vary as the cube root of the explosive weight. Thus, when the crater dimensions are known for a given weight of explosive, the crater dimensions may be obtained for any other explosive weight by simply using the cube root scaling relations. The apparent crater size is dependent upon the bomb's penetration depth at the time of detonation, and the target medium. The penetration depth at time of detonation is, in turn, dependent upon fuze functioning time, impact angle, speed at impact, soil medium, and bomb shape and weight.

g. In medium soil, which is defined as fifty per cent sand, thirty-five per cent silt, and fifteen per cent clay, optimum cratering is obtained when a bomb is detonated at about ten to twelve feet penetartion depth. At penetration depths of between five and fifteen feet, good cratering is achieved. Optimum cratering in soft soil, defined as thirty percent sand, thirty per cent silt, and forty per cent clay, is obtained with penetration depths of twelve feet. Good cratering effects can be obtained with penetration depths of two to twenty feet. In hard soil (ninety-five percent sand, five percent silt, and no clay), optimum cratering is achieved with a six feet penetration depth, and good cratering will be obtained with detonation at penetration depths of from three to ten feet.

Part 3.

The Environmental Impact of Military Use of the Kahoolawe Island Target Complex.

1. Description of Environmental Factors Concerning Kahoolawe Island.

a. Kahoolawe is the smallest of the eight main islands of the Hawaiian archipelago. It is eleven miles long and six miles wide at the widest point; containing an area of approximately forty-five square miles or twenty-eight thousand acres. The maximum elevation is 1,477 feet. The island lies approximately six and three-quarters miles southwest of the island of Maui.

b. Ancient Hawaiians referred to Kahoolawe in chants and histories. Archeological remains on the island include heiaus, fishing shrines, house foundations, camp sites, burial places and miscellaneous structures, such as walls, terraces, and piles of stones. The early monarchy used Kahoolawe as a penal colony. While the island was populated during the monarchy and probably before that, the lack of water has always been a serious problem preventing sizeable populations of an enduring character. Early populations probably never exceeded 150 and were primarily fishermen.

c. Water is only procurable after heavy rains, when the craters on the uplands act as natural reservoirs.

d. The monarchy leased the island to one R. C. Wyllie in 1858 as a sheep ranch. A contemporary visitor estimated that the island could possibly pasture ten thousand sheep and five thousand goats. Importation of diseased sheep rendered Wyllie's venture a failure. A subsequent lease, in 1894, to Elisha H. Allen was to run for fifty years at $250.00 per year. In 1876 King Kalakaua visited the island, reporting the presence of 20,000 sheep and 10 horses, commenting that the island was fit only for grazing. Sheep ranching continued to 1880 when cattle were introduced for the first time. Subsequent lessees were reported to have had 900 cattle and 1,200 sheep.

e. The monarchy was overthrown and a United States Territory formed with the consent of the intervening Republic

without disturbing existing leases in the 1890's. By 1909, the vegetation had deteriorated so badly and soil erosion by wind and water was so severe that the legislature voted not to renew the 50 year lease. On 25 August 1910, the island was proclaimed a forest reserve and steps were taken to terminate the existing lease. In 1913 a botanist reported the island the most eroded of any in Hawaii, the only native tree growth remaining being about a dozen Erythrina monosperma (Wiliwili). He found most of the soil gone from the island, having been eroded by the wind after overbrowsing by cattle, sheep and goats. All that remained was hard-pan. On windy days, he found visibility practically nil and the island enshrouded in clouds of red dirt sometimes carried by the south winds across the channel to Maui Island where it was deposited on sugar cane fields.

f. The island was removed from the Forest Reserve in 1918 and leased in 1919 at $100 per year rent with the proviso that the lessee eliminate all goats and sheep within a year and limit stocking of other animals to not more than 300 cattle and 20 horses and mules. The lessee never wholly exterminated the goat and sheep population.

g. A lighthouse was constructed in 1927 and, during the period from 1919 to 1941, a fence was built across the island to keep the remaining goats and sheep confined to the rocky hills on the eastern slope. Five thousand trees and hundreds of pounds of Australian saltbush and grass seed were planted.

h. Occupancy of the island was taken by the U. S. Army in 1941 for unrestricted military operations under a sublease allowing the prime lessee to continue ranching operations, but all cattle were removed from the island later that year following a declaration of a unlimited national emergency. Bombardment and bombing by the Navy was permitted by the Army until the sublease was transferred to the Navy in 1945. Existing leases were cancelled following World War II and the Territorial Government permitted the Department of the Navy to enter and use the island for naval purposes. On 20 February 1953, under Executive Order 10436, the island was placed under the jurisdiction of the Secretary of the Navy for the use of the United States for Naval purposes with approximately twenty-three acres reserved for the Coast Guard. The executive order required eradication of all cloven-hoofed animals or reduction to a number not exceeding two hundred. Conservation efforts by the Territorial Government were encouraged. The island was not included in the act of Congress enabling Hawaii to be admitted to statehood but provisions of

the act and the prior executive order require its conveyance to the State when the Department of the Navy determines it to be no longer of use, at which time both the state's sovereignty and ownership of the property would commence.

i. Early visitors reported the slopes of the island to be corrugated with gulches fifty to two hundred feet deep which contained water only during a few days of each year. Stiff tradewinds blew over the island nearly every day. Rainfall records were not preserved but record remnants indicate annual rainfalls of from 23 to 27.5 inches, most rain falling between November and April.

j. Nine water retention units with a total capacity of about 1,090,000 gallons were constructed on the island in early years; but most relied upon flood gulches and rapidly filled the reservoirs with silt. Lack of water caused livestock deaths during drouth seasons when the island was used for grazing. Seven wells have been dug at various times, most of them in the gulches. Five were reported inoperable in 1940 and the two remaining wells were very brackish. An early writer indicates these wells were originally fresh and supported livestock. He suggested that the spread of the kiawe tree in the gulches robbed the zone of saturation of most of the fresh water that reached the water table of the wells in prior years. The kiawe trees grew green in the gulch floors, nurtured by sub-irrigation. A commentator in 1940 observed that, while the tree was valuable in preventing soil erosion, its lowering of the water table near the wells was an adverse effect from its growth.

k. Two spring-like seeps were noted on a cliff at Kanapou Bay, one yielding about one-quarter pint per minute and the other about one-half pint. The observer, in 1940, concluded that ground water near sea level probably was fairly high in salt content, suggesting that if a drilled well is tried, it should be sunk as far inland as possible and should not extend more than about ten feet below the water table.

l. Four different soil structures have been found. They are:

(1) Keahue Series, consisting of well-drained silty, clay loam at elevations from 600 to 1500 feet with average rainfalls of 15 to 25 inches, consisting of a surface layer of dark, reddish-brown, granular and subangular, blocky, silty, clay loam about ten inches thick over a subsoil consisting of a dark, reddish-brown, subangular,

blocky, silty, clay loam about fifty inches thick. The substratum is soft, weathered, basically igneous rocks. The permeability of this soil is moderate, run-off slow, and the erosion hazard is moderate. The available water-holding capacity is about 1.3 inches per foot of soil. Root penetration to four feet is possible;

(2) Blown-out land on the wind-swept plateaus of the island on slopes ranging from zero to fifteen per cent. Elevations range from 1,000 to 1,700 feet with an annual rainfall of 15 to 25 inches and strong winds. Most areas are barren and eroded, consisting of compact subsoils or soft weathered rocks. Five to ten per cent of the area has hummocks or small dunes that are partially stabilized by pitted beardgrass. Water runoff is rapid, with some erosion.

(3) Jaucus Series, consisting of excessively drained, sandy, calcareous soils developed from coral and sea shells occurring in narrow strips adjacent to the ocean on the coastal plains. Elevations range from sea level to one hundred feet with an annual rainfall of ten to forty inches. The Jaucus soils are single grain, pale brown, sandy, and over sixty inches deep. In many places, the surface layer is dark brown, resulting from an accumulation of organic matter and alluvium. The soil has rapid permeability with slow run-off and slight water erosion hazard, but wind erosion hazard is severe if the vegetation is removed. Available water-holding capacity is 0.5 to 1.0 inch per foot of soil; and

(4) Lualualei Series, consisting of well-drained clay soils formed from alluvium and colluvium found on the coastal plains on nearly level and gently sloping alluvial fans. Elevations range from near sea level to 125 feet with an annual rainfall of 18 to 20 inches. The surface layer is a very dark grayish brown, prismatic, very sticky and very plastic clay about ten inches thick with similar subsoil. This soil cracks widely upon drying. Permeability is slow, run-off is slow, and erosion hazard is slight. The available water-holding capacity is about 1.4 inches per foot of soil with a high shrink-swell potential.

m. Plant life consists of four trees--the iron-wood, wiliwili, eucalyptus and kiawe trees, twelve grasses (none of them legumes), eight varieties of shrubs, fourteen herbs, two vines and two succulents. Animals include two

varieties of rat, one of mouse, common house cats, goats, sheep, one variety of quail, two of doves, the skylark, the mockingbird, mynah, White eye, English sparrow, plover, Kentucky cardinal, California Linnet, several common sea birds, the silver pheasant and the wild turkey. Of the game bird species present, none have populations large enough to provide any significant or sustained hunting opportunities and nome are known to be endangered species. Control of the existing domestic sheep and goat population is done by hunting during visits to the island of target survey and maintenance teams (see appendices C and D).

n. In 1970, the Navy initiated action directed toward resolving some of the environmental problems existing on Kahoolawe Island, sending a team of natural resource scientists to Kahoolawe to examine the plants, animals and soils at six sites. Removal of unexploded ordnance from the test sites was commenced in September by Explosive Ordnance Disposal specialists. In January, 1971 seedlings and equipment were transported to the island by Navy helicopters in a planting project with the cooperation of the Hawaii Division of Forestry. Field work in forest survey has been commenced and one rain gage established. Seventy-six per cent of the tree and shrub seedlings planted in January were alive three months later. Eight species of grass and legumes were planted at the six test sites and showed generally good survival. Evaluations are incomplete at this time, preventing recommendatior concerning extensive reforestration projects.

o. Since 1968, sport fishing in the waters adjacent to the island has been permitted during periods when no live firing was taking place.

p. The feral goat has been considered present in sufficient population to have a potential for public hunting. While this subject has been under study, lack of public transportation and refrigeration facilities, as well as the hazard to hunters from weapons exercises or unexploded ordnance have, when combined with the availability of other hunting areas, prevented either development of public sport hunting or slaughter of the goat population for use as food in charitable institutions.

q. Thirteen beaches with total frontage of about four miles represent slightly less than two percent of the archipelago's total. Twelve are unsuitable for recreational use because of small size, surrounding sheer cliffs and direct exposure to winds (see appendix E).

r. The "Smuggler's Cove" beach with three-quarters of a mile of frontage, is located on the southwestern end of the island and contains several old military buildings of temporary construction providing limited facilities for shore parties. Absence of fresh drinking water, cooking facilities and adequate sanitary facilities decreases the potential utility of the Smuggler's Cove beach for public recreation. Nearby Maui County, with a population of 47,747, has thirty-seven significant beaches. This fact, combined with the requirement that recreational users have boats of the proper size or access to helicopter services, renders the utility of Smuggler's Cove beach additionally doubtful. The beach is, however, unaffected by the present use of other portions of the island for military purposes.

s. The island contains no areas of particular aesthetic value. It is hot, dry, and dusty, partially covered by scrub kiawe trees and pili grass, providing little inducement for hiking, camping or picnicking.

t. The island is uninhabited by man. Naval personnel who visit the island for target maintenance remain for 4 nights and 5 days. They sleep in a wooden barracks, and deploy with adequate food, water and other necessities to sustain them during this period.

2. Beneficial Environmental Effects of Military Use of Kahoolawe Island.

Some of the bomb craters contain vegetation which appears to survive quite well during the driest months of the year. This appears to be due to a combination of factors:

a. The craters contain pulverized soil as a result of the bomb explosion which is similar to that of a field prepared for planting;

b. The soil contains some beneficial elements and compounds resulting from the explosion that fertilize plants;

c. The crater bottom, at a distance from the terrain surface, provides an area for vegetation growth that is out of the prevailing strong northeast trade winds and acts as a trap for drifting seeds and loose, wind-borne topsoil; and

d. The crater tends to catch a percentage of rainfall during runoff, thus supplying a meager amount of water to support plant growth.

3. Direct and Secondary Environmental Consequences of Military Use of Kahoolawe Island.

a. As the island is uninhabited, there are no apparent effects on man's health, welfare or surroundings from military use of the target complex upon the island itself. Prevailing trade winds blow toward the west and southwest. Occasional winds in the opposite direction might carry dust generated by use of live ordnance across the channel to Maui island, but the coastal area affected on Maui is primarily agricultural. Such dust would precipitate relatively quickly, so air pollution effects on Maui would be negligible. The dust would add to the topsoil used for agricultural purposes.

b. Aircraft flight patterns from Oahu military airdromes by Kahoolawe-bound aircraft fly over the Pacific and not over populated areas so noise impact from aircraft en route is slight to nonexistent.

c. The total impact on the island environment resulting from the continued live aerial bombing and shore bombardment of the target complex on Kahoolawe Island is pollution, in varying degrees, of the air, the terrain, island water (to the extent seasonally present) and surrounding ocean waters. Noise is created. There is destruction of vegetation, wildlife and marine life.

d. The explosion of ordnance releases various chemicals into the atmosphere. Since the prevailing winds on the island of Kahoolawe are from the northeast approximately 95 per cent of the time, most of the chemicals released by the detonation of an explosive are directed in a southwesterly direction, away from land masses. These chemicals, some of which may be considered pollutants, are mixed rapidly with the surrounding air and, for all practical purposes, are dissipated.

e. Unusual southerly winds, coupled with certain atmospheric trapping conditions, were the cause of reverberations and noise experienced by Maui residents in early 1969. After a careful examination of the situation, the Navy instituted several procedures in order to avoid further public annoyance. Targets were relocated to the west one-half of the island, restrictions were imposed on the size and type of ordnance used, and stricter air control procedures with more precise flight approaches were directed. The atmospheric conditions are carefully monitored and live

ordnance is not permitted when adverse sound-focusing conditions are present. The size of the bombs are limited to 500 lbs. Planes carrying the bombs are not allowed to fly over any land other than the target. When the aircraft carriers are operating, the pilots are given special briefings to follow flight path procedures precisely. Since these procedures have been instituted, complaints have been reduced considerably. On 21 May 1971, two members of Environmental and Preventive Medicine Unit No. 6 went to the island of Maui in connection with a noise survey of selected areas. Bomb explosions were very faintly heard on only one site, but the sounds did not register on a meter carried by these personnel. No vibrations were noted. At a few other points, smoke from the explosions could be seen but no sound was detected (see appendix I).

f. Most targets on the island are built on eroded, compact subsoil and soft weathered rock which existed prior to the military use of the island. The explosion of any type of ordnance on this exposed subsoil and rock loosens and powders it to varying radii and depths, depending upon the type of ordnance used and the density of the subsoil and rock. The surrounding area is littered with metal bomb or shell casing fragments. Explosions which may occur in surrounding waters due to malfunction or pilot error result in the release of pollutants into both air and water, and the destruction of nearby fish and other marine life. Occasionally, explosive ordnance fails to detonate on impact which results in "dud" ordnance falling on or beneath the surface of the ground or into the surrounding waters. Detonation failure on impact does not remove the hazard of such ordnance, however.

g. The only significant source of fresh water on Kahoolawe is rainfall, estimated to average between eighteen and twenty-seven inches annually. Rain waters collect in the craters that are formed in the terrain by shore bombardment and aerial bombing. When a camouflet occurs, elements and compounds released as a result of the explosion vent to the surface and escape or remain partially confined. Rain water may absorb these elements and compounds and become, to a degree, polluted. Rain water either accumulates in the craters and percolates downward, or may be carried as surface runoff to the ocean.

h. The vegetation which exists on Kahoolawe consists primarily of common exotic species. Since very

limited amounts of vegetation exist within the target area, the detonation of a bomb or ship projectile must be a considerable distance off-target before any appreciable vegetation destruction occurs. The destruction of vegetation by explosives is not of such significance as to cause deterioration of the vegetative cover of the island as shown by the fact that the vegetative cover of the island has generally improved since it has been under military control. There have been five endemic plants reported from Kahoolawe. Of these five, four have not been reported after 1860 and were probably destroyed during periods of overbrowsing in the late 19th Century. The fifth species may still exist on the island.

i. Various species of mammals, birds and marine life inhabit Kahoolawe and the surrounding waters. All six species of mammals which occur on Kahoolawe are generally considered pests of no scientific or aesthetic value. Feral goats and feral sheep are routinely shot during target maintenance trips in order to protect the vegetation from overgrazing.

j. Most of the birds which occur on Kahoolawe are exotic species of common distribution throughout Hawaii and in certain other parts of the world. The remaining species include the plover, which migrates to Hawaii each winter, and three species of common indigenous sea birds which inhabit the cliffs around the island. Since most targets are located in an open erosion scar, and since wildlife tend to seek santuary in gulches or in the air over the ocean when aircraft or ship bombardment begins, the destruction of wildlife through explosions is negligible.

k. The species of marine life in the waters surrounding Kahoolawe are presumed to be the same as those surrounding the other main islands. No individual inventories are available from any of the main islands. These waters are routinely used by local sport fishermen on weekends when bombing and bombardment are not taking place. Since there are no targets currently located in the waters surrounding Kahoolawe, the destruction of marine life would occur only through pilot error or an inadvertent weapon release.

4. <u>The Effects of Conservation Efforts</u>.

Feral goats and sheep have been shot by U. S. Navy ordnance personnel during target maintenance trips to the

island in order to protect the vegetative cover of the island from overgrazing. The results of these efforts have been that the area of forest growth, primarily the species kiawe, has increased greatly during the period the island has been under military control. Grass cover has increased generally. The eroded area in the center of the island has decreased appreciably. Beginning in 1970, the Navy entered into cooperative efforts with several conservation agencies to initiate planting of various species of trees, shrubs, and grass which may prove beneficial to the island. These include 2,319 tree seedlings of 33 species and 8 species of grasses and legumes totaling 10,100 square feet. These plantings were made in six study plots located on various parts of the island. In April, 1971, state and federal conservationists visited the island of Kahoolawe to inspect the revegetation efforts. The result of their findings are most favorable (See Appendix F):

a. Seventy-six percent of 2,319 tree and shrub seedlings planted in January were alive three months later, in April of 1971.

b. The eight species (11 accessions) of grass and legumes which were planted at each of the six sites showed generally good survival.

It must be borne in mind that the period evaluated was the rainy season of the year and hence most conducive to plant survival. Further evaluation must be made after periods of drought.

No recommendations for extensive reforestation project can be made at this time--at least two years must elapse before evaluating species performance.

Part 4.

Adverse Environmental Effects Which Cannot be Avoided in Military Use of the Kahoolawe Island Target Complex

1. Continuing craterization, creation of camouflets and scoring of the surface by ricochets can be anticipated as well as litter of the area by metal fragments of bombs and shell casings. Inert practice ordnance is sometimes retrievable, but the expense of collection of metallic casing fragments for recycling makes such collection impractical.

2. Continuing air pollution by dust and gases from explosions can be anticipated.

3. Continuing minor soil and subsurface water pollution from chemical compounds resulting from explosions can be anticipated.

4. While every effort is made, through training, improvements in weapons release and targeting systems, and by other means to prevent pilot or bombardier errors, malfunctioning of weapons release or targeting systems and improper trajectory tracking by air-to-ground weapons and shells from surface ships, early bomb drops or short gunnery shots will recur. Partly, this must be anticipated because the personnel involved are in the phases of training where full expertise has not been developed, thus necessitating the training with inert and live ammunition. At any event, misses will unavoidably recur.

5. The environmental effect of Kahoolawe Island Target Complex weapons exercises upon the ecology or ecological systems of other nearby islands of the Hawaiian archipelago will remain negligible.

6. The extent to which human health or safety, aesthetically or culturally valuable surroundings, standard of living, or other aspects of man's life will be sacrificed or endangered by continued military use of Kahoolawe Island is considered negligible.

Part 5.

Alternatives to Military Use of the Kahoolawe Island Target Complex.

1. Return of the Island to Agriculture, Grazing or Forestation.

a. The experience of the latter 19th century and early 20th century with sheep, goat and cattle raising is not favorable, insofar as it is considered to be an indicia of the economic utility of the island for grazing. Of course, modern concepts of pastureland management, use of hybrid legumes and soil-retaining pasture grasses, and use of fertilizers were not known by the early stockmen. Use of modern agricultural survey and planning techniques and selection of breeds of sheep or cattle most adaptable to the climate and environment might make restoration of grazing economically feasible within at least marginal profit expectations. A rather substantial capital investment would be required to provide stock and proper pasture growth, preventing realization of short-term profit from such a venture. No efforts have been made since before World War II to drill wells or create dams or reservoirs. Water for stock or irrigation would be a condition necessary to development, and insufficient information is available at present to indicate the economic feasibility of well-drilling or dam building.

b. Some of the soil structures are similar to those found on other islands in the Hawaiian archipelago used for sugar cane, pineapple and other agricultural operations. Further soil sampling, surveying and evaluation would be required before the potential of the island for commercial agriculture could be properly evaluated. The soil structures in areas used for targets would probably have no commercial agricultural value.

c. A forestry survey is in progress but requires two years for the collection and evaluation of data. Reforestration for the purpose of increasing ground cover and reducing erosion may prove feasible, but there are presently substantial doubts that the island would ever produce timber of commercial value at a profit.

2. Public Hunting and Other Recreational Uses for the Island.

a. Only the feral goat is present in sufficient population to support public hunting. Lack of transportation

facilities to the island, refrigeration facilities for the catch, accommodations while on the island and related factors make it unlikely that public hunting would become a significant island use even if weapons operations were to be stopped and the island opened for this purpose. The hazard from unexploded ordnance would also be a problem. Specialists in wildlife management and public recreation indicate that the ready availability of public hunting elsewhere in the surrounding islands reduces the potential utility of Kahoolawe for this purpose.

b. Sport fishing in the island's adjacent waters during periods when no weapons exercises are being conducted has been permitted since 1968. The actual extent of it is unknown. Remains from ancient Hawaiian settlements indicate the island was primarily used by them as a site for settlements of fishermen so long as fishing remained good. There has been no reported systematic study of the waters adjacent to Kahoolawe insofar as commercial tuna or other fishing is concerned, but even if commercial fishing were to be found excellent, fishing boats would use canneries and refrigeration sources in existence on the other islands, so the likelihood of development of such facilities on Kahoolawe presently appears remote.

c. The Smuggler's Cove beach is the only beach on the island with recreational potential and this potential is reduced by lack of sanitary facilities, limited cooking facilities and water as well as by difficulty of access. The presence of other beaches on the nearby islands, presently more than adequately filling the beach recreation needs of the inhabitants and visitors, is also a factor reducing the likelihood of recreational development of the Smuggler's Cove beach. The beach is unaffected by weapons exercises.

3. Suggested Useage of the Island for a Thermonuclear Power Plant and Related Projects.

a. An article in the Honolulu Star-Bulletin of 5 October 1970, reported a proposal for utilization of Kahoolawe Island prepared by the University of Hawaii microbiologist, Dr. Kaare R. Gunderson, under a grant from the Hawaiian Electric Company. The study was an outgrowth of Dr. Gunderson's researches on the aquacultural fertility of deep ocean water. He proposed contruction of either a thermonuclear or a geothermal power plant, built underground, on the elevated eastern end of the island. Nutrient-rich coolant water would be piped into the power plant from the submarine canyon south of Kanohio Bay on the southern side of the island. Electric power would be distributed statewide through cables on the sea floor between the islands. The power

plant would be accompanied by a desalination plant. A series of fishponds would be constructed along the twelve-mile northwest coastline and the coolant water, still containing nutrients, would be fed into the fishponds after being ejected from the power plant. About 2,000 acres of such ponds could be constructed. The temperature, salinity and nutrient content of the water in the individual ponds could be regulated through the combination of the power plant cooling system and the desalination installation. About 2,000 acres on the western side of the island would be developed into an industrial park with canneries and other plants to process the sea food and agricultural products harvested on the island. Desalination would be based on distillation using excess waste heat from the power plant. Irrigation of some 15,000 acres of dry land was contemplated. The Flexibility of the Aquaculture system involved was thought to offer a unique opportunity for scientific experimentation as well as commercial production of high-priced seafoods, such as oysters, lobsters, crabs, shrimp and prawn, high-protein blue-green algae and brine shrimp. Commercial salt could be produced from the desalination process and rare metals might be extracted. Treatment plants for aquacultural and agricultural wastes would recycle them for use as fertilizer.

b. In 1971, the Hawaii State Legislature, by concurrent resolution, requested that a feasibility study of the establishment and construction of a nuclear power plant on Kahoolawe Island be conducted by the state's Department of Planning and Economic Development, with the assistance of the College of Engineering and the Environmental Center of the University of Hawaii. The study, with cost estimates and estimated environmental effects is to be presented to the legislature prior to the 1972 session. $275,000 was appropriated for the study.

4. Alternative Navy-Controlled Sites for Continuation of Military Weapons Training if the Kahoolawe Island Target Complex is Disestablished.

a. There are three Navy-controlled sites where weapons exercises similar to those in use at the Kahoolawe Island Target Complex have been considered. They are San Clemente Island, Kaula Rock, and PMRF Barking Sands.

b. The target island of San Clemente, sixty-three miles off the coast of California, is used frequently by the Navy as a shore bombardment target. Unfavorable weather conditions are sometimes a problem and ships based in Hawaii would have to travel roughly 2,500 miles to conduct their training exercises.

c. Kaula Rock is an island that protrudes sharply from the sea to a height of approximately five hundred fifty feet above sea level at its highest point. It is seven-tenths of a mile long and one-third of a mile wide at its widest part. The island is half-moon-shaped, covering an arc of about two hundred degrees. Its total area is one hundred eight acres. The terrain is sloped in various directions. The only area of relatively level surface is at the northern end of the island. There are no beaches of any kind and access to the island by boat is extremely hazardous. The island is located about one hundred forty five miles from Naval Air Station, Barbers Point, Hawaii. The southeast corner of Kaula Rock is the aim point for all ordnance expenditures.

d. Kaula Rock is not considered an acceptable alternative because:

(1) The size and terrain of the island make it virtually impossible to construct an adequate number of targets which could be used as close air support targets.

(2) The training achieved by the users would not sufficiently duplicate a true combat situation;

(3) Heavy vehicle targets could not be placed on the island by ship transport or helicopter;

(4) There are no facilities for the berthing and messing of personnel; and

(5) The island is inhabited by thirteen species of sea birds with an estimated population of one hundred thousand birds.

e. Early in 1970, a preliminary survey of the feasibility of conducting "no ordnance" bombing at the Pacific Missile Range Facility, Barking Sands, was conducted. This study revealed that, by using procedures similar to those used for aerial mine laying exercises, it was possible to conduct bombing runs that could be scored electronically

by the equipment presently installed at the facility. Although some training benefit might be derived by use of such a system, it is not considered to be an acceptable alternative to the use of Kahoolawe Island.

f. The training of aviators and surface units in the art of air-to-surface and surface-to-surface weapons delivery must be conducted in a realistic environment which simulates actual combat conditions as closely as possible in order to achieve the most positive transfer of learned responses to a combat situation. Combat realism is obtained by diversity in types of targets within a target complex, such as:

(1) Area targets, e.g. runways, simulated industrial complexes, etc;

(2) Point targets, e.g. simulated surface-to-air missile sites, revetments, bunkers, storage tanks, trucks, etc.;

(3) Targets of opportunity, such as truck convoys;

(4) Open and easily spotted targets;

(5) Targets hidden by terrain features, or foliage;

(6) Reverse slope targets, i.e. targets located on the rear of an intervening ridge or hill (especially necessary for Naval gunnery exercises); and

(7) Varying terrain features which are useful for training in night operations, target orientation and acquisition and complete testing of the aircraft ordnance release system.

g. Facilities at Pacific Missile Range Facility, Barking Sands, cannot provide this kind of weapons training environment.

5. <u>Alternative Sites Controlled by Other Federal Agencies for Continuation of Military Weapons Training if the Kahoolawe Island Target Complex is Disestablished</u>.

a. The Air Force has no practice firing sites in Hawaii. The Army utilizes three areas as practice firing sites

in the Hawaiian area. They are the Schofield Barracks Range Complex on Oahu, the Makua Valley Impact Area, also on Oahu, and the Pohakuloa Training Area on Hawaii.

b. The Schofield Barracks Range Complex cannot be used for naval purposes. Close air support training has not been approved by the Army in this area. If it were to be approved, aircraft conducting close air support training would be forced to fly over inhabited areas of Oahu, carrying live ordnance enroute to the target area. This would create a potential hazard to the life and property of local citizens. Night operations over this range complex could be hazardous, both to pilots and to the local populace, since the range complex is surrounded by inhabited areas on all sides. Short-notice schedule changes, resulting from difficulties in use of the range complex by units of the two services, could result in the loss of valuable training. Shore bombardment by ships firing at targets in the Schofield Barracks Range Complex would be firing projectiles over the property of local citizens, creating a hazard to life and property. Shortfall hazards are obvious.

c. An essentially similar problem exists with respect to the use of the Makua Valley Impact Area, i.e., armed flights over populated areas, close air support training evolutions not presently authorized by the Department of the Army, the hazardous nature of night operations, and scheduling problems. The largest piece of explosive ordnance authorized by the Army for firing in the Makua Impact Area is the shell for a 106 mm. recoilless rifle. Most Navy ships conduct shore bombardment training with the five inch (127 mm.) gun, thus exceeding the size authorized. In addition, close air support with Mark 81 and Mark 82 bombs would exceed the dimensions authorized.

d. The Pohakuloa Training Area on the island of Hawaii has an artillery impact area that has been used occasionally by Marine aircraft from MCAS Kaneohe Bay. This unit is the predominant user of the Kahoolawe target complex--three days or two nights per week--familiarizing ground troops with employment and control in fixed-wing close air support evolutions. However, the Pohakuloa Training Area is not considered adequate to meet the Navy and Marine Corps requirements.

(1) Targets for close air support missions are large cheesecloth air panels which are laid on an accessible hillside. These panels lack permanency and are subject to easy obliteration.

(2) Marine Air Group TWENTY-FOUR training requirements for instruction of aircrews of the F-4 aircraft in techniques and procedures used in air-to-ground ordnance delivery necessitate a minimum target complex combining ring targets, strafing targets and a raked target to measure dive angles and "miss" distances. These types of targets are available at Kahoolawe but not at the Pohakuloa Training Area. Construction of targets at the latter complex does not appear economically feasible, due to limited access roads, lava formations, and subterranean ordnance duds in the lava.

(3) Even if suitable targets could be constructed, the persistent formation of a broken-to-overcast ceiling below ten thousand feet and the inherent problems of night deliveries in close proximity to two thirteen thousand foot mountain peaks makes the Pohakuloa Training Area an impracticable and unsuitable target area. A climatological study shows a ceiling of less than ten thousand feet existing thirty-six per cent of the time and fifty-seven per cent of the time during the optimum training periods from noon to early evening, precluding or seriously restricting high-dive ordnance delivery training.

(4) The distance of one hundred sixty-three nautical miles between MCAS Kaneohe Bay and the Pohakuloa Training Area increases to about one hundred eighty nautical miles.

(5) Entry to the target complex would be through a thirty mile long corridor over inhabited land, which would create a potential hazard to the populace and to property.

(6) The Army anticipates future usage of the target complex by Army units to increase. Since simultaneous air and artillery operations are not compatible and would decrease target availability and scheduling capability, utility would be much reduced for Navy and Marine Corps units.

6. Construction of Artificial Target Complex Island for Continuation of Military Weapons Training if the Kahoolawe Island Target Complex is Disestablished.

a. No formal studies have been prepared, though the question of artificial target islands was raised in connection with a target complex investigation by the Navy in another area and hypothetical construction of artificial islands on Barriles Reef and Grampus Shoals was therein considered. Very rough cost estimates indicate creation of artificial islands in the Barriles Reef area would be $272,000,000 and in the Grampus Shoals area $456,000,000.

b. The Barriles Reef construction hypothesis envisioned an artificial island three hundred acres in area constructed in forty feet of water. It would be fifteen hundred feet wide and eight thousand feet long and would contain an isolated observation tower, a helicopter pad and an overnight personnel shelter. Construction would use fill and mound material dredged from the area, totaling twenty three and six-tenths million cubic yards and rip-rap stone quarried from nearby islands and brought, by barge, to the reef. Total cubic yardage of stone would be six and nine-tenths million.

c. The hypothetical for Grampus Shoals assumed a similar construction in waters with an average depth of sixty feet. The additional water depth with the corresponding increase in fill, mound and rip-rap resulted in a higher cost estimate.

d. The environmental impact of such artificial islands upon fishing and the oceanographic environment was unexplored.

e. During discussions of the hypotheses, doubt was expressed that the capability of building a floating island of any design or size was within the state of the art. Cost estimates of two to three million dollars per acre were believed unrealistic. There would be technological problems in providing topographic features on a floating island. The islands would not be invulnerable to inert warheads.

7. Development of a Realistic Practice Bomb for Continuation of Military Weapons Training in Other Places if the Kahoolawe Island Target Comples is Disestablished.

a. Design and development of a complete practice bomb which would have the least environmental effect with

the maximum training for users would obviously be a substitute for use of live air-to-surface ordnance should the Kahoolawe Island Target Complex be closed. The Department of Defense's current inventory of non-nuclear practice bombs does not provide the ordnance team (i.e. handlers, loaders, fuzers, pilots, flight officers, etc.) with the necessary totality of training elements present when live ordnance is used in training exercises.

b. A complete practice bomb should have:

(1) The same weight, shape, construction, and other characteristics as the actual bomb it is to simulate;

(2) A fuzing capability which is identical to the bomb it is to simulate; and

(3) A minimum explosive charge sufficient to release visible smoke for spotting, but without heat, gases, blast, shock wave, noise or other associated characteristics of live ammunition.

8. Substitution of Floating Targets for Naval Gunnery Exercises if the Kahoolawe Island Target Complex is Disestablished.

Towed targets are used in Naval gunnery exercises simulating attacks upon other ships. They are not particularly useful in training for use of Naval gunfire upon shore targets since they cannot be built to simulate mountains, beaches and other topographical characteristics similar to those encountered in a combat situation involving use of Naval gunfire on shore targets. Training in the use of Naval gunfire on targets located on the rear of intervening slopes or hills and out of the line-of-sight is particularly important to maintenance of the training and readiness of gun crews and target spotters. No presently existing towed target can provide this kind of training. In view of doubts expressed on the feasibility of floating islands, previously mentioned in subparagraph 6e, design and development of such targets by the Department of the Navy is highly unlikely.

Part 6.

Relationship Between Local Short-Term Use of Man's Environment and the Maintenance and Enhancement of Long-Term Productivity.

1. Thirty years of use of the island as a target site for naval gunfire and aerial bombardment borders upon long-term use, yet the balance of the island's ecosystems--from the viewpoint of insights provided by observers of the island in its earlier years of grazing--appears to have slightly improved.

2. Continued use as a weapons target area will, in the areas affected, continue the cratering and camouflet effects from direct hits and surfact scoring from ricochets upon soil structures not considered to have short or long-term agricultural productive capability for anything other than ground cover plants of substantial biological tenacity with little commercial value.

3. The mineral content per acre of the target sites, from fragmentations, might someday prove economically worthwhile from the standpoint of salvage and retrieval of some of the metallic alloy material involved, usually brass or ferric alloys.

4. The presence of unexploded dud ordnance in the area is a major problem, a situation which has been in existence for several years without noticably adverse effect upon the human population spread within the Hawaiian archipelago. However a current sanitization program is in progress utilizing local EOD assets. When there is no longer a need for the use of the island for naval purposes, the Department of the Navy will so notify the State of Hawaii and shall, upon seasonable request, render such area, or such portion thereof, reasonably safe for human habitation.

PART 7

Irreversible and Irretrievable Commitments

An inventory of all irreversible and irretrievable commitments of natural resources involved are:

a. soil loss

b. Clearing of "dud" (non-exploded) ordnance (Safety of Personnel)

Soil Loss. The detonation of an explosive just above, at or below the terrain surface results in loosening and pulverizing of the soil in varying degrees of severity. The blast from the explosive will dislodge the soil from its present position in the form of small dust particles or larger pieces. Dust particles forced into the air will either settle back to the surface or are carried away by the wind. During the rainy season, dust particles and larger pieces of soil dormant on the terrain surface will be carried to the surrounding ocean waters.

Future Safety of Personnel. Presidential Executive Order 10436 states, "When there is no longer a need for the use of the area hereby reserved, or any portion thereof, the Navy shall so notify the Territory of Hawaii, and shall, on reasonable request of the Territory, render such area, or portion thereof, reasonable safe for human habitation, without cost to the Territory." To date it is unknown how many tons of unexploded (dud) ordnance remain on or imbedded on Kahoolawe or are lying in adjacent waters. Estimates have reached figures as high as 10,000 tons and as the shore bombardment and aerial bombing continue on the target complex, this fugure must also increase. The fact that the Island does contain unexploded ordnance is the primary reason why, during non-military use, the local citizenry has been denied access for hunting, picnicking and general recreation. However, the Navy fully recognizes and understands the requirements of the Presidential Executive Order. Presently, Explosive Ordnance experts are conducting a systematic and thorough inspection, detection and destruction of dud ordnance in non target areas of the island making them safe for human habitation.

APPENDIX A

LEGENDS AND ARCHEOLOGY

McAllister (1933) wrote: "In a Hawaiian chant on the formation of the islands there is the mere statement: 'A red rock was Kahoolawe.' " He quotes Fornander (1878) as follows:

> Kahoolawe is said to be the child of Keaukanai, the man, and Walinuu, the witch, from Holani; and the epithet of the island-child is "the farmer" - he lopa. (The island of: Ed) Molokini has no seperate settlers, but is called the navel-string - iewe of Kahoolawe.

McAllister referred to the connection of Kahoolawe as the place of embarkment for the legendary voyages to Tahiti, and quoted Malo (1903), as follows:

> When Kila was grown up he in turn sailed on an expedition to Tahiti, taking his departure it is said, from the western point of Kahoolawe, for which reason that cape is to this day called Keala-i-kahiki (the route to Tahiti).

According to McAllister, only once was Kahoolawe mentioned in interisland warfare. He quotes Fornander (1878) as stating that when Kahekili heard of the invasion of Kalaniopuu, he:

> ...sent troops to Kaupo and apparently cleared the country of the invaders, for it is said that Kalaniopuu left Kaupo and made his next descent on the island of Kahoolawe, and not finding much booty there, steered for Lahaina.

The archeological remains on Kahoolawe include heiaus, fishing shrines (ko'a), house foundations, camp sites, burial

places, and such miscellaneous structures as walls, terraces, and piles of stones. Fifty sites were found and described in detail by McAllister (1933).

> A number of the sites are undoubtedly remains of structures built since the discovery of the islands in 1778. During the early years of the monarchy, roughly from 1800 to 1850, when Kahoolawe was used as a penal colony, structures for lodging and penal purposes were said by Thrum (1902) to have been erected at Kaulaua Bay. No remains were found there, nor is there any official record of these buildings.
>
> From the remains found on Kahoolawe it is evident that there was at least a semi-permanent population on the island. The house foundations and ruins of religious structures are as permanent as the remains on any of the Hawaiian islands, but environmental conditions were such that it seems unlikely that people could have inhabited the island for an indefinite period. The lack of water has always been a serious problem. Water is only procurable after heavy rains, when the craters on the uplands act as natural reservoirs and retain water for many months.
>
> Kahoolawe, however, lacks many of the usual remains of the other islands. There are no taro terraces or irrigation ditches. An early visitor reported sweet potato terraces, but these are the only traces of former agricultural activity. There are no fishponds, no places of refuge, no fortifications, no holau slides, no petroglyphs....
>
> Similarly, the artifacts from the island in general are not typical of (the entire: Ed) Hawaiian culture but represent (only: Ed) the fishing industry. Not only were there sinkers, fishhooks, squid lures, but also implements for the manufacture of fishing equipment. No

pounding or grinding implements have ever been reported; no tapa beaters, anvils, stamps, liners; no spears, clubs, slingstones; no bowls, boxes, platters; nor any of the more carefully made and finely finished artifacts, aside from those pertaining to fishing....

The population on Kahoolawe was apparently never large. Even if all the dwelling sites notes had been occupied at a single period, there would hardly have been 150 people on the island. A population of this size could never have sustained itself for any length of time without obtaining food and water from Maui or one of the other neighboring islands.

It seems more probable that Kahoolawe served as a base for fishing peoples who, attracted by the plentiful supply of fish in the waters about the island, established semi-permanent huts, numerous fishing shrines (ko'a), and two heiaus for propitiating the fish dieties and assuring good catches. Many of these fishermen may only have made offerings at the shrines or rested for a short period. Others undoubtedly lived on the island as long as food and water were available.

The evidence of the remains and artifacts establishes these former inhabitants of Kahoolawe as Hawaiians of the time of discovery (1778). Two structures resemble the Hawaiian heiau form. They are smaller than the usual type, but not unusual, and are probably fishing heiaus. The fishing shrines (ko'a) are typical of those found on any of the other inhabited Hawaiian islands. Similarly, the dwelling sites do not differ from the Hawaiian forms....

It is evident, however, that though Hawaiian culture is not fully represented, the fishing phase is highly developed.

The lack of traditions for Kahoolawe is mute evidence of the unimportance of the island. A transient population, without taro patches and permanent abodes, with a paucity of material objects, was of little interest to avaricious chiefs and

priests and the island consequently escaped most of the interisland warfare.

....No remains were found other than those of a fishing phase of the Hawaiian culture of the eighteenth century.

Of the fifty sites described and studied by McAllister, 11 can be considered to be within the general target area, and of these, four sites are less than 500 yards from a target. These are:

Site	Description
Site No. 46	Fishing Shrines
Site No. 47	Dwelling Sites
Site No. 48	House Foundation
Site No. 49	Camp Site

It is possible that these four sites have been damaged or maybe destroyed. McAllister studied and described these sites, and removed the small artifacts he found to the B. P. Bishop Museum. Therefore, much of the scientific value of these sites has been obtained. Although these sites do not differ significantly from the several thousand other comparable sites on the main islands, their destruction would still be a loss to future generations.

APPENDIX B

DISCOVERY, OWNERSHIP, AND PREVIOUS USE OF KAHOOLAWE

> As shown on the "Chart of the Sandwich Islands" (Hawaiian Islands: Ed) dated 1779, Captain Cook discovered the eight principal islands, now known by the names of Hawaii, Maui, Molakai, Oahu, Kauai, Lanai, Niihau, and Kahoolawe, and also the two very small uninhabited islands near Niihau, now called Lehua and Kaula, and the small island called Molokini lying between Maui and Kahoolawe. (Morris, 1934)

Rule by Island Kings and the Beginning of the Monarchy

At the time of discovery, each major island was ruled by a separate king. In 1790, King Kamehameha brought them all under his authority and began a dynasty which lasted until 1893.

The accounts of early voyages regarding Kahoolawe are brief and not very encouraging. McAllister (1933) wrote, "Many travellers did not even note the island, and others merely mentioned it." He quotes Captain King (Cook, 1784) as writing the following in 1779:

> Tahoorowa (Kahoolawe: Ed) is a small island off the S. S. part of Mowee (Maui: Ed), from which it is distant three leagues. This island is destitute of wood and the soil seems to be sandy and barren.

Myhre (1970) quotes the Pacific Commercial Advertiser (Anon., 1912) as follows:

> Vancouver was credited with giving goats to a Maui Chief who sent some to Kahoolawe to multiply.

Although the date is not known, this can be presumed to have been sometime in the 1790's or early 1800's.

> Bryan (1935) states: "Long ago, at the beginning of the 19th Century, the island (Kahoolawe: Ed) was used as a place of banishment. The men, we are told, were sent to Kahoolawe, and the women to Lanai."
>
> William Ellis, referring to the period 1822-23 wrote: "It (Kahoolawe: Ed) is low, and almost destitute of every kind of shrub or verdure, excepting a species of coarse grass." (Ellis, 1963)
>
> McAllister (1933) quotes Arago (1825) as follows: "Taouroe sera eternellement deserte, car la vie y est impossible." (Kahoolawe will forever be uninhabited because life there is impossible.)

The prediction Arago made was not entirely accurate, as the census taken in 1832 and again in 1936 credits the island with a population of 80 persons. (Bryan, 1933). Apparently, however, residence on Kahoolawe was not entirely by choice. Bryan (1935) states: "When visited in March 1841, by Lt. Budd of the United States Exploring Expedition....All the inhabitants at this time were convicts or exiles, except for two old women who lived on the northeast end. They had to bring nearly all their supplies from Maui, as only a few sweet potatoes were raised on Kahoolawe."

Myhre (1970) quotes Perkins in 1850 as reporting that on the island were akoko trees the bark of which had been chewed by goats, and some stunted wiliwili. (Restarick, 1931)

In 1858, there were about 50 persons on the island, as well as goats, pigs and dogs. (Allen, 1858)

> After the custom of using Kahoolawe as a place of banishment had ceased, attention was turned toward putting the island to more profitable uses, for we find that on August 18, 1854, Z. Kaauwai applied to the Privy Council to lease the island for 50 years at $200 per year. This application does not seem to have been approved.... (McAllister, 1933)
>
> In 1858, the first least to Kahoolawe was sold to R. C. Wyllie and the island became a sheep ranch. (Myhre, 1970) (Anon., 1858)

At that time, William Webster said that there was possible pasturage for 10,000 sheep and 5,000 goats. (Hollingsworth, 1938). Sheep were brought to Kahoolawe in that year, but the venture failed because the sheep were diseased. (Allen, 1858) (Hollingsworth, 1938)

On March 11, 1864, the entire island of Kahoolawe was leased to Elisha H. Allen for a period of fifty years, to run from January 1863, for an annual rental of $250 (McAllister, 1933). When King Kalakaua visited the island in 1876, he reported 20,000 sheep, 10 horses, and that the island was fit only for grazing. (Anon., 1876).

Myhre (1970) in quoting the Hawaiian Gazette (Anon., 1881) states that sheep ranching was continued until 1880, when A. D. Courtney and W. H. Cummins assumed the lease and planned to replace the 2,000 goats and 1,000 sheep they found with cattle, Thus introducing cattle to Kahoolawe for the first time.

The fourth lessees (Kinserly Brothers and Von Tempsky) assumed the lease April 27, 1887 and had 900 cattle and 1,200 sheep. (Myhre, 1970) (McAllister, 1933) (Judd, 1916)

Overthrow of the Monarchy, Formation of A Republic and Annexation to the United States

The rule of the Hawaiian Monarchy continued until 1893, when a revolution drove Queen Liliuokalani from the throne. An appeal was made to the United States for annexation and was rejected by President Cleveland.

A Republic was proclaimed on July 4, 1894. In 1898 a second appeal for annexation was made to President McKinley and was accepted.

Title to Kahoolawe was vested in the United States by the joint resolution of Congress approved July 7, 1898, providing for the annexation of Hawaii, which reads, in part, as follows (30 Stat. 750):

> Whereas the Government of the Republic of Hawaii, having in due form signified its consent, in the manner provided by its constitution, to cede absolutely and without reserve to the United States of America all rights of sovereignty of whatsoever kind in and over the Hawaiian Islands and their dependencies, and also to cede and transfer to the United States the absolute fee and ownership of all public Government, or Crown lands, public buildings or edifices, ports, harbors, military equipment and all other public property of every kind and description belonging to the Government of the Hawaiian Islands, together with every right and appurtenance thereunto appertaining: Therefore Resolved by the Senate and House of Representatives

> of the United States of America in Congress Assembled, That said cession is accepted, ratified, and confirmed, and that the said Hawaiian Islands tnd their dependencies be, and they are hereby annexed as part of the Territory of the United States and are subject to the dominion thereof, and that all and singular the property and rights hereinbefore mentioned are vested in the United States of America.* * *

An act of Congress approved April 30, 1900 (31 Stat. 141), established territorial government and created organic law for the Hawaiian Islands. (U.S.C. Annotated, Title 48, Sec. 491, et seq.)

This law, known as the Organic Act of 1900, provided that property such as Kahoolawe which had been ceded to the United States, would remain in the possession, and control of the Territory of Hawaii until taken for the uses and purposes of the United States by direction of the President or the Governor of Hawaii.

In 1901, B. F. Dillingham Co., Ltd. assumed the lease to Kahoolawe in an attempt to raise sugar cane. On December 28, 1903, C. C. Conradt assumed the lease to raise sheep, and again on December 28, 1906, Eben P. Low assumed the lease to continue the ranching operation. (Myhre, 1970) (McAllister, 1933) C. S. Judd (1916) wrote that in 1906 there were some 3,200 sheet on the island.

Bryan (1935) wrote: "By 1908, sheep and goats, which had gone wild, had so overrun the island, and eaten off or

or trampled down the vegetation, that it was scarcely fit for profitable farming."

LeBarron and Walker (1970, unpub.) in reviewing the history of Kahoolawe, state "By 1909, the vegetation had deteriorated so badly and soil erosion by wind and water was so severe that the Legislature voted not to renew the 50-year lease. On August 25, 1910, the island was proclaimed a Forest Reserve and steps were taken to terminate the lease before its expiration date of January 1, 1913."

They quote Rock (1913), an eminent botanist then serving as a consultant to the Division of Forestry, as follows:

> The island of Kahoolawe is the most eroded of the whole group and the only native tree growth which remains is composed of perhaps a dozen Erythrina monosperma (Wiliwili)....Most of the land on this island has no soil, all having been blown into the sea by wind, after it had been robbed of its vegetation by cattle, sheep, and goats, with which the island is overstocked. The result is that there is nothing left but pure hard-pan, several feet thickness of soil having been blown away. Even now on a windy day the island is not visible, as it is enshrouded in the cloud of red dirt which, when the south wind prevails is carried across the isthmus of the Island of Maui, to be deposited on the already fertile sugar cane fields.

LeBarron and Walker also quote a report by the Superintendent of Forestry (Anon., 1912) as showing a photograph of a lone wiliwili tree surrounded by bare, wind-swept soil, and carrying the caption, "The ultimate result of forest destruction. Two-thirds of the Island of Kahoolawe is like this."

LeBarron and Walker continue:

> Unfortunately, the Division of Forestry did not have sufficient resources to eradicate all the goats and sheep, although about 5,000 goats were destroyed between 1912 and 1918. Hence, the Superintendent of Forestry recommended that the island be removed from the Forest Reserve in 1918 and returned to the Commissioner of Public Lands. He advised that the new lease require its purchaser to eliminate all goats and sheep within one year and to limit stocking of other hoofed animals to not more than 300 cattle and 20 horses and mules. It also required that denuded areas be fenced to exclude grazing animals.
>
> The new lease was sole in 1919[1] for an annual fee of $100. Goats and sheep were greatly reduced but never wholly exterminated. (Within the first three years, McPhee removed 13,100 goats: Myhre, 1970). On December 4, 1929, Territorial Forester C. S. Judd wrote: "Getting rid of the goats has continued to be the obstacle and although the present lessee has worked valiantly on this tough job and has expended huge sums on the work, the last remaining flock of goats has been exterminated several times over but like the dragon's teeth, new crops seem to appear and from last accounts that reached me, there were some of these pests still on the island."

On December 19, 1927, Governor's Executive Order No. 308 set aside certain lands on the island of Kahoolawe for light-house purposes under the control and management of the Department of Commerce. On February 3, 1928, Presidential Proclamation No. 1827, set aside the same area (23.3 acres) for the same purposes and placed it under the control and management of the Department of Commerce, subsequently the United States Coast Guard.

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[1] To Angus McPhee of Maui.

On May 23, 1933, General Lease No. 2341 was re-issued to McPhee and Baldwin (Kahoolawe Ranch Co.) for a period of 21 years.

During the period from 1919 to 1941, a fence was built across the island to keep the remaining goats and sheep confined to the rocky hills of the east side. Five thousand trees and hundreds of pounds of Australian saltbush and grass seed were planted. According to Ashdown (1947) by January of 1941, McPhee and Baldwin had invested $190,000 in the island.

APPENDIX C

THE NATURAL RESOURCES OF KAHOOLAWE

Rainfall and Water Sources

In writing of his archeological investigations on the Island of Kahoolawe, McAllister (1933) wrote:

> The lack of rain is apparently the single factor that hampered the development of the island, for had there been sufficient precipitation to foster the growth of vegetation and to supply fresh water, Kahoolawe would not have differed from any of the inhabited Hawaiian Islands. The eight mile channel between Kahoolawe and Maui did not represent an isolating factor. There was of old, in fact, constant communication between all of the Hawaiian Islands, and during at least one period (about 33 generations prior to 1900) voyages between Hawaii and Tahiti were recorded in tradition.

On December 7, 1857, P. Nahaolelua, Governor of Maui, and Ioane Richardson made a report to King Lot Kamehameha after inspecting the island. Stearns (1940) quotes their report as follows:

> There is no fresh water there (Kahoolawe: Ed) but the old residents stated that during rainy times fresh water may be found in small pools, but these waters did not last, when the sunny times came they soon dried up.
>
> There are not many places on this island where brackish water may be found. There is only one brackish water which is accessible seen by us, at Ahupuu Harbor, this brackish water being on the northwest of said island.
>
> And the old residents informed us, that there is another brackish water on the southeast (this was corrected by Stearns to read southwest: Ed)

> side of said island, it is in a bad place under the cliff at a place called Waikaluu, another brackish water is at the east side of said island, at Kanapou, the well where Kalaepuni was murdered. These are the only three places known where brackish water may be found on Kahoolawe.

Harold T. Stearns, Senior Geologist, U. S. Geological Survey, spent from March 5, to March 13, 1939, in field work on the Island of Kahoolawe. Several routes across the island and practically the entire shore line were traversed on horseback. The cliffs on the south and north ends of Kanapou Bay were traversed on foot. The high cliffs bounding the east and south shores were examined from a boat. The purposes of the work was to map the geology, to study the ground-water resources, and to determine whether it is feasible to develop water by means of wells. Stearns (1940) stated: "It is obvious with the rainfall so small that only small supplies of water can be recovered."

> The slopes of the island are corrugated with gulches 50 to 200 feet deep, but only during a few days each year do they contain streams....Stiff tradewinds blow over the island nearly every day. They come from the east, however, rather than the northeast, because they are deflected by the bulky Haleakala Volcano, on Maui, while lies in their path....Kahoolawe is probably the windiest island in Hawaii.
>
> Rainfall is recorded at four gages on the island, but the records have not been preserved. According to Manuel Pedro, the maximum rainfall at any gage was 23 inches in 1936, 27.5 inches in 1937, and 24.5 inches in 1938. These figures are only approximate as the amount of rain in the gage is estimated rather than measures....Mr. Pedro states that the annual

> rainfall is almost the same at all stations regardless of the altitude. This may be in part due to the fact that most heavy rains are kona storms which are general....
>
> Most of the rains fall during the months of kona or south winds from November to April, but during some years the rainfall is fairly well distributed. Since 1919 the highest observed fall during a single storm was about four inches. The lowest annual rainfall since 1919 probably occurred in 1926 and was about 18 inches; the highest occurred in 1927 and was about 27 inches. Kahoolawe is too low to cause the winds to lose much of their moisture; hence its semi-arid condition.

Stearns (1940) also discussed the nine catchment units with a total capacity of approximately 1,090,000 gallons which had been constructed on the island, and stated that since most of these were supplied by flood waters from several heavily eroded gulches they rapidly filled with silt. No information is available as to the percentage of this capacity which was actually filled at any time, but it is of importance to note that during 1941, the Kahoolawe Ranch Company was forced to remove cattle from the island, and that many died prior to removal because of a drought (LeBarron and Walker, 1970, unpup.)

Stearns also discussed the seven wells which had been dug at various times on the island. Five of the seven wells were inoperable at the time of his writing. The two wells tested were very brackish (Ahupu well, 312 grains of salt per gallon; Hakioawa well, 1,210 grains per gallon). Stearns (1940) wrote the following:

> The equipment found and reports of visitors to the island seem to indicate that the wells in Ahupu and Hakioawa gulches yielded water suitable for stock until about 1900. E. P. Low states that when he leased the island on December 28, 1906, these wells yielded potable water for stock except during dry months. Angus McPhee reports that he drank potable water from the Ahupu well about 1917. It appears that about 50 Hawaiians obtained drinking water from wells in these gulches during historic time, and that the Kinsersleys likewise pumped water for stock from the wells they dug in the same gulches while they leased the island. Thus, there has been apparently a progressive decrease in the quantity of ground water in the gulches, until by 1919 no water potable for stock remained. Although rainfall records are not available, there is ample evidence from gages on all the other islands, that the rainfall has been abundant everywhere in the Territory from 1937 to 1939, and that there was no progressive desiccation prior to 1919. Some cause other than a change in precipitation, therefore, seems to have caused the water from these wells to become salty. The spread of the kiawe tree is coincident with the decrease in the fresh ground water supply. It may be that they consume by transpiration much of the rain water that formerly percolated to the zone of saturation and supplied these wells. Thick stands of these trees cover the gulch floors and doubtless rob the zone of saturation of most of the fresh water that reaches the water table in the vicinity of the wells. These trees are now green throughout the year by subirrigation. It appears, therefore, that the kiawe tree is not always beneficial for improving water supplies, even though it may be very valuable, as on Kahoolawe, to prevent soil erosion.

Stearns (1940) also located two seeps on the cliff at Kanapou Bay. One yielded about one-fourth pint per minute, and the other about one-half pint per minute. He also mentions four resistivity stations occupied by G. R. MacCarthy in 1939. Of the four stations, the highest computed altitude

of the water table above sea levels was 1.5 feet, and stated: "The exact quality of the water near sea level at these station is not known, but is probably also fairly high in salt." His only recommendation regarding the possibility for development of water sources on the island was: "If a drilled well is tried, it should be sunk as far inland as possible and should not extend more than about ten feet below the water table."

Soils

Four general soil types have been found on the island of Kahoolawe. These are as follows:

Keahue Series. The Keahue series consists of well-drained silty clay loam soils developed from basic agneous rocks. Elevations range from 600 to 1500 feet. Annual rainfall is 15 to 25 inches. Mean annual soil temperature is 73 deg. F.

Typically, the surface layer is a dark reddish brown, granular and subangular blocky silty clay loam about 10 inches thick. The subsoil is a dark reddish brown subangular blocky silty clay loam about 50 inches thick. The substratum is soft weathered basic igneous rocks.

Permeability of this soil is moderate, run-off to slow, and erosion hazard is moderate. Available water-holding capacity is about 1.3 inches per foot of soil. Roots may penetrate to four feet or more.

Blown-out Land.[1] This land type occurs in the wind-swept plateau of Lanai and Kahoolawe. Slopes range from 0 to 15 percent. Elevations range from 1,000 to 1,700 feet. Annual rainfall is 15 to 25 inches. Strong winds are common. Most areas are barren and eroded to compact subsoils or to soft weathered rock. Subsoils are similar to Kanepuu, Lahaina, and Keahua soils. Five to ten percent of the area has hummocks or small dunes that are partially stabilized by pitted beardgrass. Runoff is rapid, and the erosion hazard is severe.

[1](The term "Blown-out" refers to the erosive action of winds, and not to explosive ordnance: Ed.)

(Kahoolawe)

Jaucus Series. The Jaucus series consists of excessively drained, sandy, calcareous soils. The soils developed in sand from coral and sea shells deposited by wind and wave action. They occur in narrow strips adjacent to the ocean on the coastal plains. Elevations range from sea level to 100 feet. Annual rainfall is 10 to 40 inches. Mean annual soil temperature is about 75 deg. F.

Typically, the Jaucus soils are single grain, pale brown, sandy, and more than 60 inches deep. In many places, the surface layer is dark brown as a result of accumulation of organic matter and alluvium.

Permeability is rapid, and run-off is very slow to slow. The water erosion hazard is slight, but wind erosion hazard is severe if vegetation is removed. Available water-holding capacity is 0.5 to 1.0 inch per foot of soil.

old alluvium

Lualualei Series. The Lualualei series consists of well drained clay soils formed from alluvium and collusium. These soils are on the coastal plains on nearly level and gently sloping alluvial fans. Elevations range from near sea level to 125 feet. Annual rainfall is 18 to 30 inches but is as low as 10 inches on Lanai. Mean annual soil temperature is about 75 deg.. F.

Typically, the surface layer is a very dark grayish brown, prismatic, very sticky and very plastic clay about 10 inches thick. The subsoil has the same color, consistence and texture. These soils crack widely upon drying.

Permeability is slow, run-off is slow, and erosion hazard is slight. Available water holding capacity is about 1.4 inches per foot of soil. The shrink-swell potential is high. Because of the high shrink-swell potential, considerable care is required when using this soil as a site for buildings or highways.

(Whitesell, 1971a)

Plant Life

Lamoureux (1970) lists 76 species of plants (excluding garden or crop plants) which have been reported from Kahoolawe. Of these, five are endemic (found only on Kahoolawe and nowhere

else), 27 are indigenous (found on Kahoolawe naturally, but also found elsewhere naturally), and 44 are exotics (species which have been brought to the island by man). See Appendix D.

The following list of plants were found on Kahoolawe in June of 1970 and April of 1971. (Whitesell, 1971a and 1971b) by H. K. Yanamura.

Botanical Name	Common Name
Grasses	
Andropogon pertusus	Pitted beardgrass
*Andropogon nodosus	Wildergrass
Cenchrus echinatus	Sandbur
Chloris inflata	Swollen fingergrass
Chloris virgata	Feather fingergrass
Cynodon dactylon	Bermuda grass
*Dactyloctenium aegyptium	Beach wiregrass
Digitaria sp.	Crabgrass
Eragrostis sp.	Lovegrass
Heteropogon contortus	Piligrass
*Panicum torridum	Kakonakona
Setaria verticillata	Bristly foxtail
Trees	
Casuarina sp.	Ironwood
Erythrina sandwicensis	Wiliwili
Eucalyptus sp.	Eucalyptus
Prosopis pallida	Kiawe
Shrubs	
Acacia farnesiana	Klu
*Desmanthus virgatus	Desmanthus
Indigofera suffruitosa	Indigo
Lantana camera	Lantana
Leucanena leucocephala	Koa haole
Nicotina glauca	Tree tobacco
Sida fallax	Ilima
Waltheria americana	Uhaloa
Herbs	
Atriplex semibeccata	Australian saltbush
*Bidens pilosa	Spanish needle
Desmodium triflorum	Three-flowered beggarweed
Emilia sonchifolia	Flora's paintbrush

*Euphorbia glomerifera	Graceful spurge
*Euphorbia glomerifera	Garden spurge
*Euphorbia prostrata	Prostrate spurge
Phaseolus lathyroides	Wilde peabean
*Salsola pestifer	Russian thistle
*Solanum nodiflorum	Popolo
Sonchus oleraceus	Sow thistle
Verbesina enelioides	Golden crownbeard
Xanthium strumarium	Cocklebur
*Zinnia pauciflora	Zinnia

Vines

Ipomoea cairica	Hairy morning-glory
*Licopersicon pinellifolium	Wild tomato

Succulents

Agave sisalana	Sisal
Batis maritima	Pickleweed

This list includes twelve exotic species (marked by asterisks) not included in the list prepared by Lamoureux. These bring the plant total to 88 species. The fifty-six exotic and twenty-seven indigenous plants, are by reason of their distribution elsewhere, of no special botanical interest.

The five endemic species, which may be considered of botanical interest are as follows:

Lipochaeta bryanii nehe
Collected only by Bryan in 1931

Lipochaeta kahoolawensis nehe
Collected only by Reme in 1851-55

Gouvania cucullata
Collected only by Remy in 1851-55

Gouvania remyi
Collected only by Remy in 1851-55

Neraudia kahoolawensis
Collected only by Lydgate in the 1860's

The status of these endemic plants is unknown. If, however, some or all have disappeared from the island, a fact almost impossible to ascertain, it should be borne in mind that four of the five species were collected only by early collectors, in the period between 1851 and the 1860's, prior to the periods of prolonged overgrazing. The fifth species, which was collected only by Bryan in 1931, was collected from an area far from the target areas.

Animal Life

Mammals: The following list includes the 11 species of mammals which have been reported from Kahoolawa, including the date first introduced (if known) or first reported, and the data last reported. The five species, apparently no longer present on the island are marked with asterisks.

Class Mammalia
Order Rodentia
Family Muridae

Rattus r. rattus - Roof rat
Probably introduced shortly after the discovery of Hawaii. Listed by Tomich (1969) as present on the island: 1971 - presumed to be present.

Rattus exulans hawaiiensis - Polynesian rat
Probably introduced in prehistoric times. Listed by Tomich (1969) as present on the island in 1969. 1971 - presumed to be present.

Mus musculus domesticus - House mouse
Probably introduced shortly after the discovery of Hawaii. 1971 - present on the island.

Order Carnivora
Family Canidae

*Canis f. familiaris - Domestic Dog
1858 - reported present on the island (Allen, 1858). Feral dogs were probably destroyed during the various ranching operations, and ranch dogs were probably removed at the termination of ranch operations in 1941. 1971 - none present on the island.

Family Felidae

Felis catus - House cat
1936 - reported abundant in a feral state on the island. (Franck, 1937) 1971 - present on the island.

Order Perissodactyla
Family Equidae

*Equus c. caballus - Domestic horse
1876 - King Kalakaua reported ten horses present on the island (Anon., 1876). There were probably horses present on the island from the time of the first least in 1858 until the last cattle were removed in 1941. 1971 - none present on the island.

*Equus asinus x Equus caballus - Mule
1913 - One mule reported on the island (Judd, 1938).
1917 - None present on the island.

Order Artiodactyla
Family Suidae

*Sus scrofa scrofa - Pig
Probably introduced in prehistoric times.
1858 - Present on the island (Allen, 1858)
1913 - None present (Forbes, 1913).

Family Bovidae

*Bos tarus - Domestic Cattle
1880 - First introduced (Hawaiian Gazette, 1881).
1941 - Removed from island (LeBarron and Walker, 1970 unpub.).

Capra h. hircus - Domestic goat
Probably introduced in the period between 1790 and 1800.
1858 - Present on the island (Allen, 1858).
1971 - Present on the island.

All of the above listed mammals are exotics, of common distribution within the remainder of the State of Hawaii and in many other parts of the world. With the possible exception of the dog and cat, which in a feral state may be or have been important predators on some of the herbivores and murids, they can be considered as all being detrimental to the island.

Birds: The following list includes the 19 species of birds which are known to have been reported from the Island of Kahoolawe. Of these, two were probably misidentified and these are shown in parenthesis. Two species, apparently no longer on the island, are marked with asterisks.

Class Aves
  Order Pelicaniformes
    Family Phaethontidae

Phaethon rubricauda - Red Tailed Tropic Bird

This species is an indigenous sea bird which occurs also around Oahu and is abundant in the northwest islands of the State (Anon., 1967). Munro (1944) stated: "This tropic bird breeds on the islands of the Hawaiian Chain, Bonin Island, and most likely it is the subspecies that is so common on the Phoenix and Equatorial Islands. It breeds on Niihau in the main group, and very likely on remote cliffs of other islands, especially Lanai." It was reported by LeBarron and Walker (1970, unpub.) as present on Kahoolawe in 1970. 1971 - present on the island.

Order Galliformes
Family Phasianidae

Lophortyz gambelli - Gambel's Quail

This species is an exotic game bird which was established on Kahoolawe from an introduction by Mr. H. A. Baldwin in 1928 (Munro, 1944). It was reported by LeBarron and Walker (1970, unpub.) as present on the island in 1970. 1971 - present on the island.

(Lophortyz californica vallicola - Valley Quail)

This species, identified by Stearns (1940) only as "Valley Quail," with no scientific name given, was probably a mis-identification of the species shown above, which is a similar species.

*Gennaeus nycthemerus - Silver Pheasant

This species, an exotic game bird which is often kept in semidomesticity as an ornmental, was reported by Stearms (1940) as being present on the island in 1939. 1971 - none known to be present on the island.

Phasianus versicolor - Japanese, Blue, Green, or Versicolor Pheasant

This is an exotic game bird which was reported by Gaum (1933) on Kahoolawe. 1971 - status unknown.

(Phasianus colchicus mongolicus - Mongolian Pheasant)

This species, identified by Stearns (1940) only as Mongolian Pheasant with no scientific name given, was probably a mis-identification of the pheasant shown above which is a similar species.

*Meleagris gallopavo - Wild turkey

This species is an exotic game bird which was reported by Stearns (1940) as numbering 500 on the island in 1939. 1971 - none present on the island.

Order Charadriformes
Family Charadriidae

Pluvialis dominica fulva - Pacific Golden Plover

This species is a migratory game bird which breeds elsewhere and visits all the Hawaiian Islands in the winter. It is present on Kahoolawe seasonally in small numbers.

Family Laridae

Anous stolidus - Common Noddy Tern

This species is an indigenous sea bird common throughout the State of Hawaii and on the Northwestern Islands. The Hawaii Audubon Society (Anon., 1967) reports that it also has a wide distribution throughout the warmer oceans of the world. It was reported by LeBarron and Walker (1970, unpub.) as present on the island in 1970. 1971 - present on the island.

Anous minutus melanogenys - Hawaiian Tern

This species is an indigenous sea bird found on the main Hawaiian islands and on many of the smaller islands in the northwest part of the chain. It is also found in warmer parts of the Atlantic and Pacific Oceans. (Anon., 1967). Reported by LeBarron and Walker (1970, unpub.) as occurring on Kahoolawe. 1971 - present on the island.

Order Columbiformes
Family Columbidae

Geopelia striata - Barred Dove

This species is an exotic game bird. Stearns (1940) reported "doves" on Kahoolawe in 1939, but did not give a scientific name. He may have referred to this or the following species or both. LeBarron and Walker (1970, unpub.) report this species on Kahoolawe, in 1970. 1971 - present on the island.

Streptopelia chinensis - Lace necked dove

(See Stearns above) This species is an exotic game bird reported by LeBarron and Walker (1970, unpub.) as present on the island in 1970. 1971 - present on the island.

Order Passeriformes
Family Alaudedae

Alauda arvensis - Skylark

This species is an exotic bird found in other parts of Hawaii, New Zealand and Europe. It was reported by LeBarron and Walker on Kahoolawe in 1970 (1970, unpub.) 1971 - present on the island.

Family Mimidae

Mimus polyglottus - Mockingbird

This species is an exotic song bird found in other parts of Hawaii and the continental United States. It was reported by LeBarron and Walker (1970, unpub.) as present on Kahoolawe in 1970. 1971 - present on the island.

Of the two species which apparently no longer occur on the island, the silver pheasant has been released on several occasions elsewhere in the State of Hawaii, and although it has survived for a period, it is apparently not adapted to the Hawaiian environment and has never become established anywhere in the State. It probably suffered a similar fate on Kahoolawe. Likewise, both domestic and wild strains of the turkey have from time to time been introduced to various parts of the state, and in many instances have survived and reproduced for a period and then disappeared for unknown reasons. Munro (1944) attributes such disappearances to possible disease. If, as is probable this species no longer occurs on the island, it is possible that its demise was occasioned by the extreme drought during the 1940's, predation by feral cats, the unidentified disease mentioned by Munro (1944) or a combination of these or other factors. More recent introductions elsewhere in the State, have again re-established turkey populations on the islands of Hawaii, Lanai, Molokai, Oahu, and Kauai.

Family Sturnidae

Acridotheres tristis - Mynah

This exotic species is classed as a song bird and is found throughout the State and in other parts of the world. Stearns (1940) reported it on the island in 1939. 1971 - present on the island.

Family Zosteropidae

Zosterops palpebrosus japonicus - White eye

This is an exotic song bird common throughout the State and in other parts of the world. It was reported on Kahoolawe in 1970 (LeBarron and Walker, 1970 unpub.). 1971 - present on the island.

Family Ploceidae

Passer domesticus - English Sparrow

This exotic species is classed as a song bird and is common throughout the State of Hawaii, the Continental U.S., and in other parts of the world. Stearns (1940) mentioned only "sparrows" without giving a scientific name, but it is assumed that he referred to this species. This species was not reported by LeBarron and Walker (1970, unpub.), however, they occur on all the islands adjacent to Kahoolawe and since the flight distance to Kahoolawe is not excessive, they are presumed to still occur on Kahoolawe in 1971, at least occasionally.

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Family Fringillidae

Richmondena cardinalis - Red or Kentucky Cardinal

This exotic song bird is common throughout the State of Hawaii and elsewhere in the continental United States. It was reported present on Kahoolawe in 1970. (LeBarron and Walker, 1970, unpub.). 1971 - presumed to be present.

Carpodacus mexicanus frontalis - California Linnet

This exotic species is common throughout the State of Hawaii and elsewhere in the continental United States. It was reported present on Kahoolawe in 1939 by Stearns (1940) and in 1970 by LeBarron and Walker (1970, unpub.). 1971 - present on the island.

Excluding the two probable mis-identifications, 17 species of birds have been reported from Kahoolawe. Of these three are common indigenous sea birds, one is a migratory game bird, seven are exotic song birds, and six are exotic game birds.

With the exception of the silver pheasant and the wild turkey, all other species are of common distribution throughout the State of Hawaii and elsewhere in the world and are of no particular scientific interest on the Island of Kahoolawe.

Of the game bird species present, none of the populations are large enough to provide a significant or sustained hunting opportunities.

PLANTS RECORDED FROM KAHOOLAWE

By

Charles H. Lamoureux
Department of Botany, University of Hawaii

May 1970

This list includes those higher plants which have been collected on the island of Kahoolawe, as evidenced by collections preserved in herbaria or notes made by reliable observers. It does not include species reported only from gardens or crop plants.

Mr. Russell LeBarron of the Division of Forestry, Hawaii State Department of Lands and Natural Resources (1969 and 1970 observations), Mr. E. H. Bryan, Jr. of the Pacific Scientific Information Center, Bernice P. Bishop Museum, and Mrs. Sheila B. Myhre, a student at the University of Hawaii, have been of great help to me in compiling this list.

For each plant on the list the following information is given:

Botanical name; Hawaiian or haole name; the last record from Kahoolawe (observer and date); and information as to whether the species is native or introduced:

* = species endemic to Kahoolawe (found only on Kahoolawe and no place else on earth)

N = species native to the Hawaiian Islands, but found on other islands as well as Kahoolawe.

X = species introduced to the Hawaiian Island by man.

FERNS

N Doryopteris decipiens (Hook.) J. Sm. "iwa iwa"
Forbes, 1913

Appendix
D

MONOCOTYLEDONS

AMARYLLIDACEAE - Amaryllis family

X *Agave americana* L. "century plant"
(or *A. sisalana*) "sisal"
Still on island, LeBarron (Species uncertain)

GRAMINEAE - Grass family

X *Andropogon pertusus* (L.) Willd. "pitted beardgrass"
Still on island, LeBarron

X *Cenchrus echinatus* L. "sandbur", "umealu"
Bryan, 1931
Still on island, LeBarron

X *Cynodon dactylon* (L.) Pers. "Bermuda grass",
Bryan, 1931; photo, 1939 "manienie"
Still on island, LeBarron

X *Chloris inflata* Link "swollen fingergrass"
Bryan, 1931
Still on island, LeBarron

X *Chloris virgata* "feather finger grass"
Still on island, LeBarron

X *Digitaria sp.* "kukaepua'a"
Reported by Nahaolelua and Richardson, 1857

N *Eragrostis variabilis* gaud. "kalamalo"
Reported by Nahaolelua and Richardson, 1857

N *Heteropogon contortus* (L.) Beauv. "piligrass"
Still on island, LeBarron

X *Melinis minutiflora* Beauv. "molasses grass"
Stearns, 1939

X *Panicum maximum* Jacq. "Guinea grass"
Bryan, 1931

X *Setaria verticillata* (L.) Beauv. "bristly foxtail"
Still on island, LeBarron

N *Sporobolus virginicus* (L.) Kunth "'aki'aki"
Bryan, 1931

LILIACEAE - Lily family

X Cordyline terminalis (L.) Kunth — "ti"
Stearns, 1939

DICOTYLEDONS

ARALIACEAE - Panak family

N Reynoldsia sandwicensis Gray — "ohe makai"
Reported by Forbes, 1913, as formerly present

ASCLEPIADACEAE - Milkweed family

X Asclepias curassavica L. — "butterfly weed", "lau-lele"
Bryan, 1931

BATIDACEAE

X Batis maritima L. — "pickle weed", "akulikuli-kai"
Still on island, LeBarron

CACTACEAE - Cactus family

X Opuntia megacantha Salm-Dyck — "panini"
Bryan, 1931
Still on island, LeBarron

CAPPARIDACEAE - Caper family

N Capparis sandwichiana DC. — "puapilo"
Bryan, 1931

CASUARINACEAE - Casuarina family

X Casuarina sp. — "ironwood"
Still on island, LeBarron

CHENOPODIACEAE - Goosefoot family

X Atriplex semibaccata R. Br. — "Australian salt bush"
Still on island, LeBarron

X Chenopodium sp. — "lambs quarters"
Forbes, 1913

COMPOSITAE - Sunflower family

X Acanthospermum australe (Loefl.) Ktze — "star bur"
Bryan, 1931

X	Emilia sonchifolia (L.) DC. Bryan, 1931	"Flora's paintbrush"
X	Heterotheca grandiflora Nutt. Bryan, 1931	"telegraph plant"
*	Lipochaeta bryanii Sherff Collected only by Bryan in 1931	"nehe"
N	Lipochaeta connata (gaud.) DC. Collected only by Remy in 1851-1855	"nehe"
*	Lipochaeta kahoolawensis Sherff Collected only by Remy in 1851-1855	"nehe"
X	Sonchus oleraceus L. Forbes, 1913	"pualele"
X	Tridax procumbens L. Bryan, 1931	"coat buttons"
X	Verbesina encelioides (Cav.) Benth. Bryan, 1931 Still on island, LeBarron	"golden crown-beard"
X	Xanthium strumarium L. Bryan, 1931 Still on island, LeBarron	"cocklebur", "kikania"
	CONVOLVULACEAE - Morning glory family	
N	Ipomoea pes-caprae (L.) Sweet Bryan, 1931	"beach morning glory"
X	Ipomoea sp. Bryan, 1931	"morning glory"
N	Jacquemontia sandwicensis Gray Bryan, 1931	"pa'u-o-Hi'iaka"
X	Merremia aegyptia (L.) Urban Davis, 1961	"hairy merremia"
	EPACRIDACEAE - Epacris family	
N	Styphelia tameiameiae (Cham.) F. Muell Reported by Forbes, 1913, as formerly present	"pu kiawe"
	EUPHORBIACEAE - Spurge family	
X	Euphorbia hirta L. Forbes, 1913	"hairy spurge"
N	Euphorbia multiformis H. + A. Stokes, 1913	"akoko"
X	Euphorbia thymifolia L.	"thyme-leaved spurge"
	GOODENIACEAE - goodenia family	
N	Scaevola taccada (gaertn.) Roxb. Bryan, 1931	"beach naupaka"
	LEGUMINOSAE - Pea family	
X	Acacia farnesiana (L.) Willd. Still on island, LeBarron	"klu"

X	Cajanus flavus DC. Bryan, 1931	"pigeon pea"
X	Desmodium triflorum (L.) DC. Forbes, 1913	"three-flowered beggarweed"
X	Desmodium uncinatum (Jacq.) DC. Bryan, 1931	"Spanish clover"
N	Erythrina sandwicensis Deg. Few trees still on island, LeBarron	"wili wili"
X	Indogofera suffruticosa Mill. Still on island, LeBarron	"indigo", "iniko"
X	Leucaena leucocephala (Lam.) dewit Still on island, LeBarron	"Koa haole"
X	Mimosa pudica L. Forbes, 1913	"sensitive plant"
X	Phaseolus lathyroides L. Bryan, 1931	"wild bean"
X	Prosopis pallida (H & B ex Kunth) HBK Still on island, LeBarron	"Kiawe"
	MALVACEAE - Mallow family	
N	Abutilon incanum (Link) Sweet Forbes, 1913	"ma'o"
N	Gossypium tomentosum Nutt. Forbes, 1913	"ma'o", "Hawaiian cotton"
N	Hibiscus brackenridgei gray Collected only by Remy in 1851-1855	"ma'ohauhele"
N	Sida sp. Still on island, LeBarron	"ilima"
	MYOPORACEAE - Myoporum family	
N	Myoporum sandwicense (DC.) Gray Reported by Forbes, 1913, as formerly present	"naio"
	MYRTACEAE - Myrtle family	
X	Eucalyptus camaldulensis Dehnh.	"Murray red gum"
X	Eucalyptus citriodora Hook.	"lemon-scented gum"
X	Eucalyptus sp. At least three species still on island, LeBarron	"Eucalyptus"
X	Psidium guajava L. Stearns, 1939	"guava"
	NYCTAGINACEAE - Four o'clock family	
N	Boerhavia diffusa L. Bryan, 1931	"alena"
	PAPAVERACEAE - Poppy family	
N	Argemone glauca var. inermis Deg. and Deg. Bryan, 1931. This variety was known only from Kahoolawe	"pua Kala"

PORTULACACEAE - Portulaca family

N Portulaca lutea Sol. "akulikuli"
Forbes, 1913

N Portulaca sclerocarpa Gray "ihimakole"
Collected only by Lydgate in1860's

RHAMNACEAE - Buckthorn family

* Gouania cucullata St. John

* Gouvania remyi St. John
Both species collected only by Jules Remy, 1851-1855

SANTALACEAE - Sandalwood family

N Santalum ellipticum Gaud. "sandalwood","iliahi"
Collected by Remy in 1851-1855, and by Stearns in 1939

SAPINDACEAE - Soapberry family

N Dodonaea viscosa L. "a'ali'i"
Reported by Forbes, 1913, as formerly present

SOLANACEAE - Tomato family

N Lycium sandwicense gray "'ohelo Kai"
Bryan, 1931

X Nicotiana glauca grah. "tree tobacco"
Still on island, LeBarron

STERCULIACEAE - Cocoa family

N Waltheria americana L. "hialoa", "uhaloa"
Still on island, LeBarron

URTICACEAE - Nettle family

* Neraudia kahoolawensis Hbd. "oloa"
Collected only by Lydgate in 1860's

VERBENACEAE - Verbena family

X Lantana camara L. "lantana"
Still on island, LeBarron

X Verbena litoralis HBK. "ha'uoi"
Still on island, LeBarron

ZYGOPHYLLACEAE - Caltrop family

N Tribulus cistoides L. "nohu"
Forbes, 1913

APPENDIX E

BEACH RECREATION IN KAHOOLAWE

Moberly (1964) inventoried the beaches within the inhabited islands of the State of Hawaii, and described 111 significant beaches. His findings show:

	Miles of Coastline		
	Total	Sandy	Beaches[2]
Hawaii	305.5	19.4	10
Maui	158.8	32.6	21
Lanai	52.3	18.2	4
Molokai	105.9	21.9	12
Oahu[1]	129.0	50.3	27
Kauai	113.4	41.2	26
Niihau	43.0	19.0	11
TOTAL	907.9	202.6	111

[1]Excludes Pearl Harbor, Sand Island, and parts of Kaneohe Bay.

[2]Very small beach areas were not described.

Kahoolawe, with a total coastline of 41.0 miles, possesses some 13 beaches with total beach frontage of approximately four miles. This represents slightly less than 2% of the State total.

APPENDIX F

VEGETATION ON KAHOOLAWE

Natural Vegetative Growth

In February of 1931, E. H. Bryan, Jr. of the B. P. Bishop Museum visited the island of Kahoolawe and prepared a map of the existing vegetation and the erosion scars.

In order to permit direct comparison, this map was reduced to the same scale as the existing vegetation map which was prepared by the U.S. Forest Service and the Hawaii Division of Forestry. In addition, the symbols used by Bryan for vegetation types were replaced by the code numbers of current use by foresters in Hawaii. These code numbers, which appear in Figures 3 and 4 are as follows:

33 - NON FOREST GRASSLAND
34 - NON FOREST PALI LAND (Cliffs: Ed)
36 - MARSHLAND
99 - OTHER (Eroded: Ed)
22-83 - NON COMMERCIAL FOREST LAND (Kiawe Type)
22-85 - NON COMMERCIAL FOREST LAND (Shrub Type)

Close inspection of Figures 3 and 4 indicate that the area of forest growth, consisting primarily of the species Kiawe (Prosopis pallida), has increased greatly during the period the island has been under military control, that grass cover has increased generally, and that the eroded area has decreased appreciably.

KAHOOLAWE

VEGETATION TYPES

FROM ORIGINAL MAP
BY E. H. BRYAN, JR. (FIELD WORK OF FEB. 1931)-
ON FILE B. P. BISHOP MUSEUM

22 - 83 NON COMMERCIAL FOREST LAND (KIAWE)
33 GRASSLAND (PILI GRASS)
36 NOT CLASSIFIED
99 ERODED

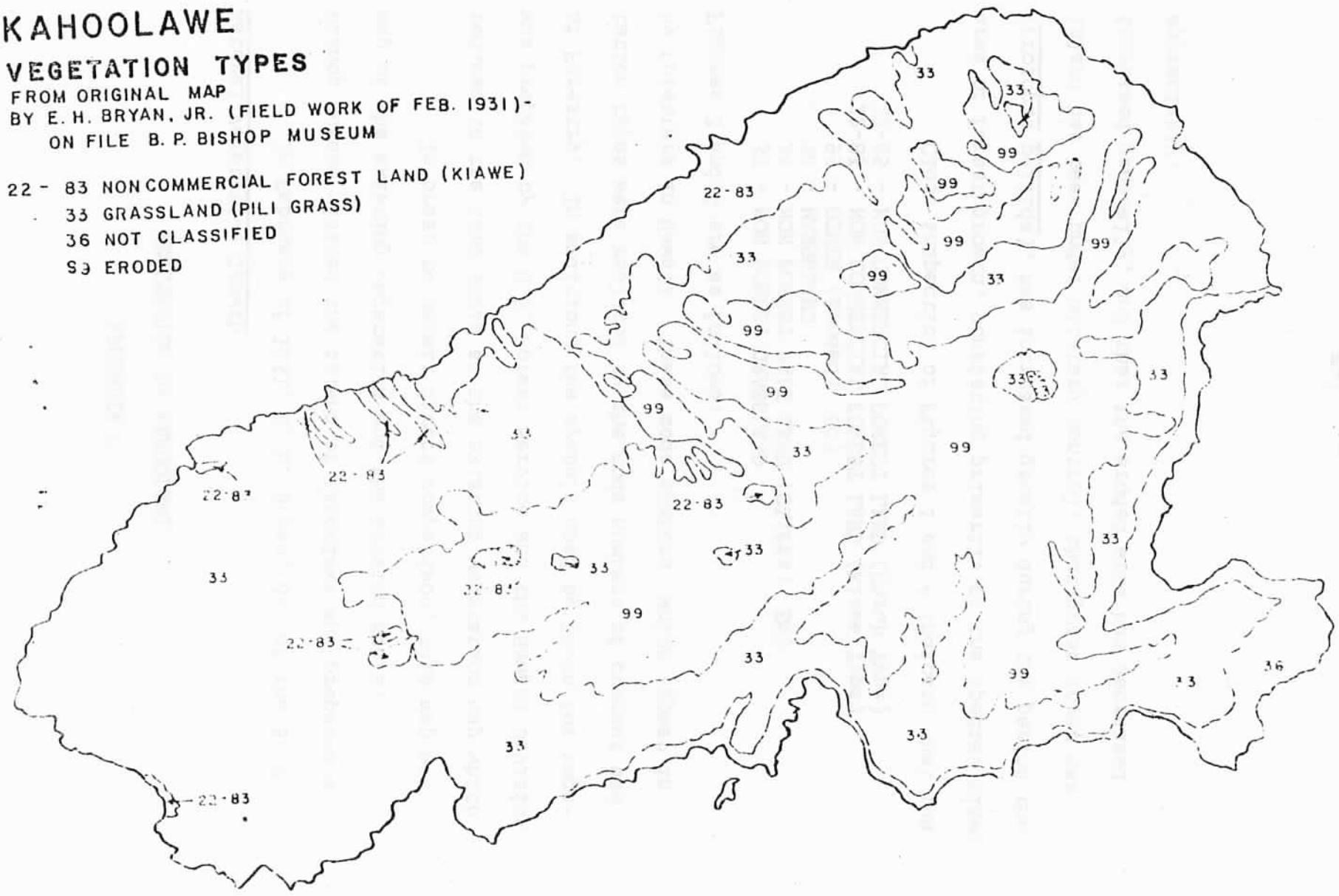


Figure (3)

Experimental Planting Trials

a. General History of Efforts, including Organizations and Individuals Involved. During the period May - June 1970, representatives of several State and Federal conservation agencies as well as several legislators were taken to Kahoolawe by the Navy for an on-site discussion and inspection.

Beginning August 1970, a series of informal meetings between representatives of the State Division of Forestry, the U.S. Forest Service and other conservation agencies, COMFAIR-HAWAII, and PACNAVFACENGCOM have been held. These have resulted in preliminary planting trials on Kahoolawe.

COMFAIRHAWAII is providing helicopter transportation for conservation teams, with Explosive Ordnance Demolition Teams sanitizing work areas and continuing to remove wild goats in conjunction with target maintenance trips.

The State Department of Land and Natural Resources, Divisions of Forestry, Water and Land Development, Land Management, and Fish and Game; the U.S. Forest Service, and

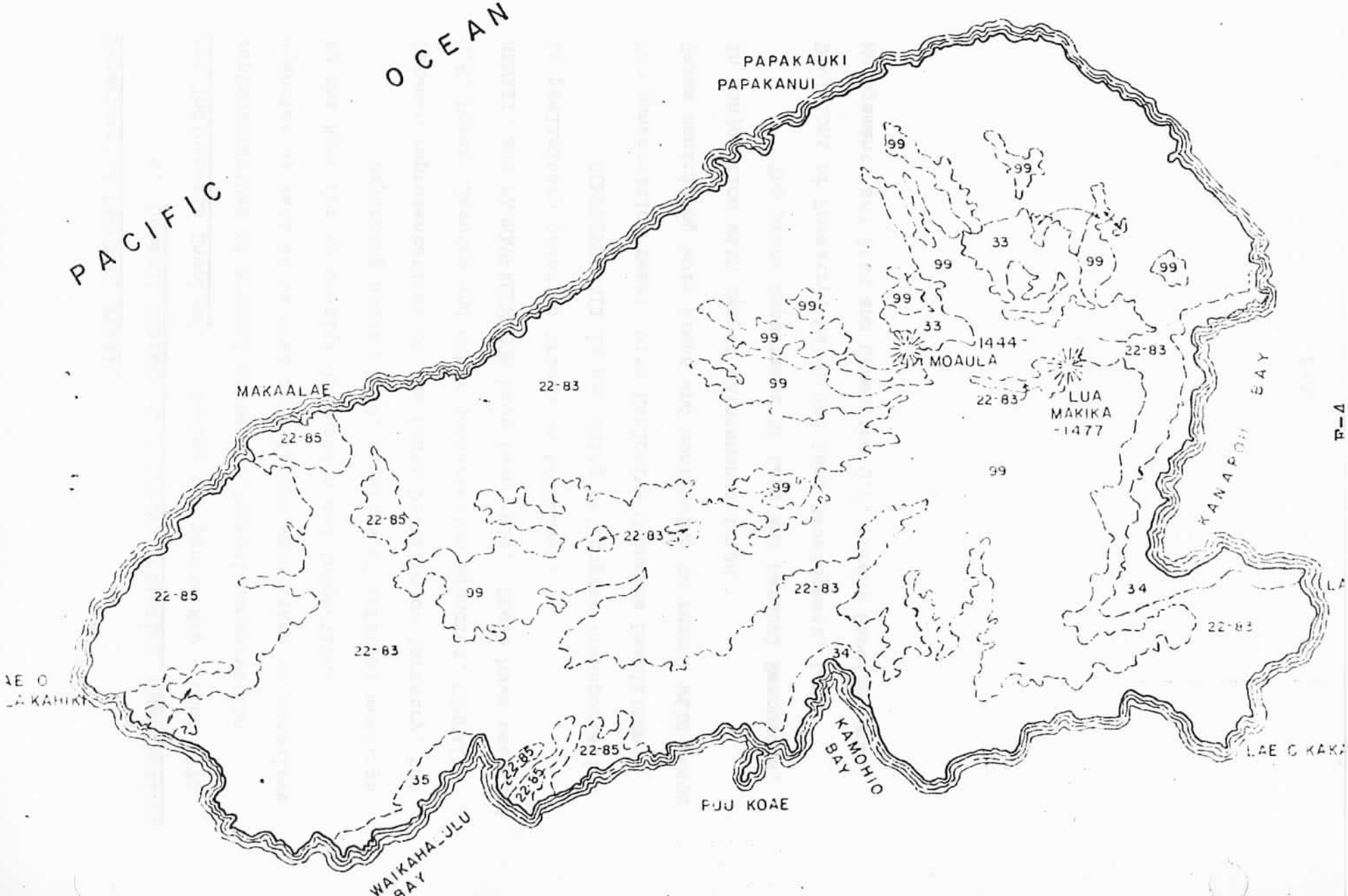

PACIFIC OCEAN
PAPAKAUKI
PAPAKANUI
MAKAALAE
MOAULA
1444
LUA
MAKIKA
1477
KANAPOHI BAY
KAMOHIO BAY
PUU KOAE
WAIKAHALULU
BAY
99
33
34
35
22-83
22-85

Figure (4)

the U. S. Soil Conservation Service are providing expertise and manpower, materials for fencing, and plants for the experimental planting of six trial plots.

Whitesell (1971a) describes the cooperative project as follows:

> In 1970, they (the Navy: Ed) initiated action directed toward solving some of the environmental problems that exist on Kahoolawe Island. During June, the Navy, in cooperation with the Department of Land and Natural Resources, sent a team of natural resource scientists to Kahoolawe to examine the plants, animals, and soils. At that time six sites were selected where one-half acre exclosures were to be built.
>
> In September 1970, the Navy sent a team of Explosive Ordnance Disposal specialists to the six sites to remove any unexploded bombs or shells present. In October, a Division of Forestry (State of Hawaii, Dept. of Land and Natural Resources: Ed) crew from Maui, under the supervision of William Sager, Assistant District Forester, constructed the six exclosures.
>
> On January 11, 1971, the personnel involved in the outplantings, along with seedlings and equipment, were transported to Kahoolawe by U. S. Navy helicopters.
>
> Participants in the field work were William Sager and seven other members of the Hawaii Division of Forestry from Maui, D. N. Palmer, and C. D. Whitesell.
>
> Paul Matsuo (State of Hawaii, Dept. of Land and Nat. Resources - Division of Water and Land Development: Ed) was on the island the morning of January 11, 1970 (note: this is an apparent typographical error - should read 1971) and established a standard rain gage at site 3. Wesley Wong, Division of Forestry, assisted in

planting site 1 and spent the next three days completing field work related to forest survey. The U.S. Navy provided two drivers and trucks, and ordnance demolition specialists. (See Figure 5 for location of the six experimental planting sites.)

b. Participants. The following list includes the names, titles, and organizations of specialists who have participated in the conservation efforts on Kahoolawe:

State of Hawaii

Department of Land and Natural Resources

Division of Forestry
Tom Tagawa, State Forester
Russel LeBarron, Staff Forester
Karl Korte, District Forester (Maui)
William Sager, Asst. District Forester (Maui)
Wesley Wong, Timber Survey Forester

Division of Land Management
Herbert Yanamura, Agricultural Land Use Specialist

Division of Water and Land Development
Paul Matsuo, Meteorologist

Division of Fish and Game
Joseph Medeiros, District Wildlife Biologist (Maui)
Ronald Walker, District Wildlife Biologist (Oahu - Kauai)

U.S. Department of Agriculture
U.S. Forest Service - Institute of Pacific Islands Forestry
Craig Whitesell, Research Forester
Gerald Walters, Research Forester

U.S. Soil Conservation Service
DeReath Palmer, Plant Materials Specialist

U.S. Navy
Fleet Air Hawaii
J. S. Elmer, Capt. U.S.N.

Pacific Division, Naval Facilities Engineering Command
Gerald Swedberg, Conservationist

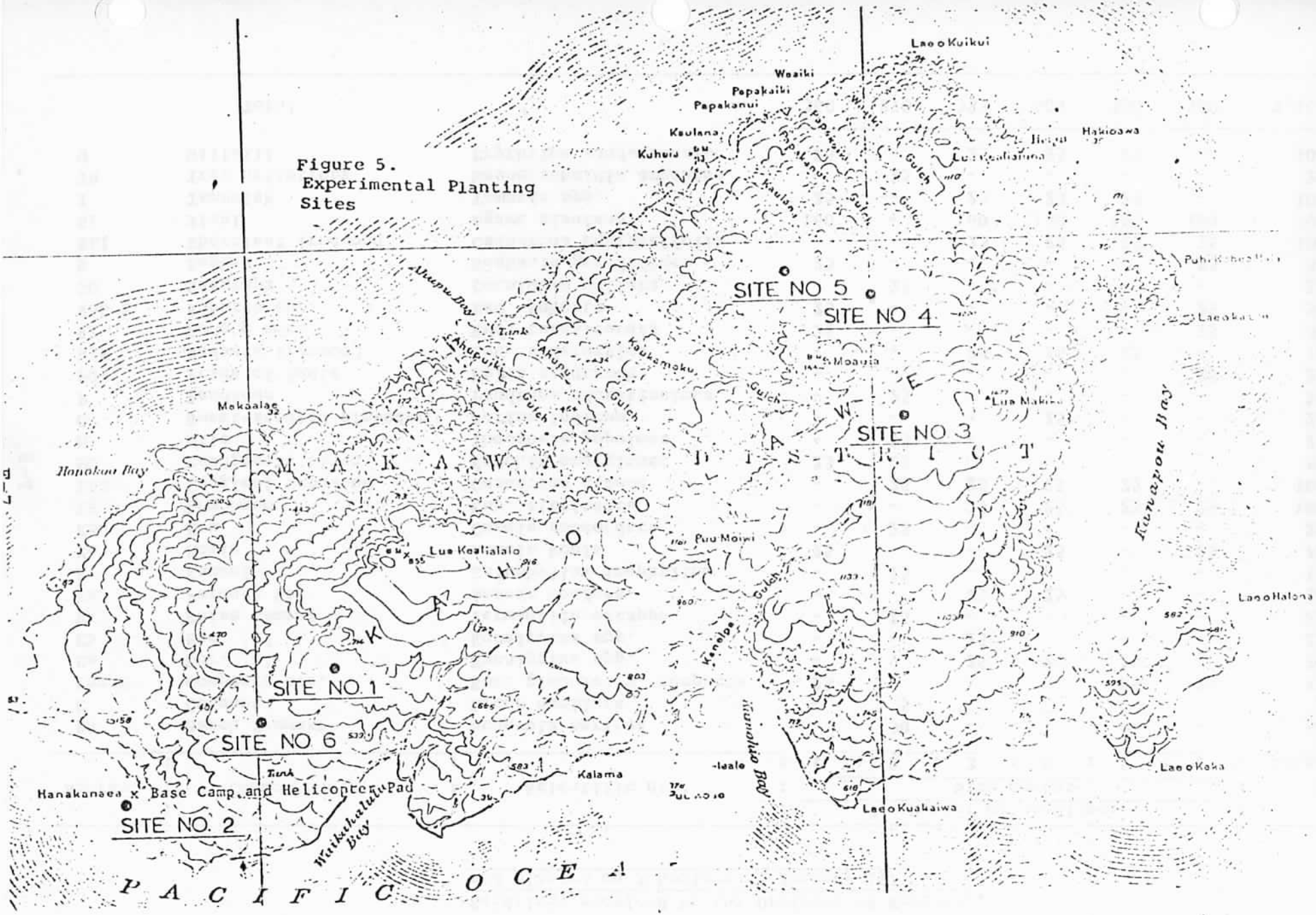


Figure 5.
Experimental Planting
Sites

--Seedlings provided by the Division of Forestry, and planted on Kahoolawe in January 1971

Abbrev.	Common name	Scientific name	Number of seedlings, Site number 1	2	3	4	5	6	Total
BN	Beach Naupaka	Scaevola sericea	-	50	-	-	-	-	50
C	Coconut	Cocos nucifera	-	5	-	-	-	-	5
Com E	Compacta euc.	Euc. globulus v. compacta	25	-	-	-	25	25	75
Ea	Euc. 'a'	Eucalyptus spp.	-	-	25	24	25	-	74
Eb	Euc. 'b'	Eucalyptus spp.	-	-	25	-	-	-	25
FK	False kamani	Terminalia catappa	-	25	-	-	-	-	25
FKo	Formosa koa	Acacia confusa	-	-	25	25	-	-	50
K	Kamani	Calophyllum inophyllum	-	15	-	-	-	-	15
Ko	Koaia	Acacia koaia	25	-	-	25	-	25	75
Kou	Kou	Cordia subcordata	-	25	-	-	-	-	25
LE	Lemongum	Euc. citriodora	-	-	25	25	25	25	100
LLI	Longleaf ironwood	Casuarina glauca	-	25	25	25	25	-	100
MO	Madagascar olive	Norohia emarginata	25	25	-	-	-	-	50
N	Milo	Thespesia populnea	-	25	-	-	-	-	25
O	Sweet-scented oleander	Nerium indicum	-	-	-	25	-	-	25
P	Pandanus	Pandanus odoratissimus	-	25	-	-	-	-	25
POI	Pride of India	Melia azedarach	-	-	-	-	-	25	25
RIE	Redbark ironwood	Euc. sideroxylon	-	-	25	25	25	-	75
RE	Redgum euc.	Euc. tereticornis	25	-	-	-	-	25	50
Rob E	Robusta euc.	Euc. robusta	25	-	-	-	-	25	50
SG	Seagrape	Cocoloba uvifera	-	25	-	-	-	-	25
S	Sesban	Sesbania grandiflora	25	-	-	-	-	25	50
SLI	Shortleaf ironwood	Casuarina equisetifolia	-	-	25	25	25	25	100
Si	Sisal	Agave sisalana	160	-	160	160	160	160	800
T	Tamarisk	Tamarix spp.	25	-	25	25	25	-	100
TH	Tree heliotrope	Messerschmidia argentea	-	25	-	-	-	-	25
W	Wiliwili	Erythrina sandwicensis	25	-	25	25	25	-	100
	Total		360	270	335	409	360	360	2,144

(Whitesell, 1971a)

Seedlings provided by the U. S. Forest Service and planted on Kahoolawe in January 1971

Abbrev.	Common name	Scientific name	Number of seedlings: Site number 1	2	3	4	5	6	Total
BP	Brutia pine	Pinus brutia	-	-	25	-	-	25	50
MC	Mediterranean cypress	Cupressus sempervirens	2	-	25	-	-	3	30
MRE	Murray redgum euc.	Eucalyptus camaldulensis	20	-	-	-	-	-	20
BCP	Black cypress pine	Callitris endlicheri	25	-	-	-	-	-	25
MRP	Murray river pine	Callitris columellaris	25	-	-	-	-	22	47
C	Gyrocarp	Gyrocarpus americanus	3	-	-	-	-	-	3
	Total		75	0	50	0	0	50	175

(Whitesell, 1971a)

-Grasses and vines provided by the Soil Conservation Service, USDA, and planted on Kahoolawe in January 1971

Hawaii Plant introduction number	Common name	Scientific name
HA-3281	Stargrass	Cynodon plectostachyus
HA-3450	Giant Bermudagrass	Cynodon dactylon
HA-247	Pangolagrass	Digitaria decumbens
HA-1129	Glycine	Glycine wightii
HA-716	Green Panic	Panicum maximum var. trichoglume.
HA-2406	Glycine	Glycine wightii
HA-696	Guineagrass	Panicum maximum
HA-333	Buffelgrass	Cenchrus ciliaris
HA-316	Buffelgrass	" "
HA-32	Buffelgrass	" "
HA-183	Piligrass	Heteropogon contortus

(Whitesell, 1971a)

COPY

RESOLUTION

NO. 241 INTRODUCED BY /s/ Joseph E. Bulgo COUNCILMAN JOSEPH E. BULGO

REQUESTING A SPECIAL MEETING TO DISCUSS THE POSSIBLE WAYS OF UTILIZING THE GOATS ON THE ISLAND OF KAHOOLAWE

WHEREAS, recent newspaper reports have indicated the slaughter of some 900 goats on the island of Kahoolawe; and

WHEREAS, said goats which possess potentially nutritious qualities are left to rot; and

WHEREAS, this wasteful disgraceful massacre is against all principles of the American Way of Life; and

WHEREAS, goat meat does provide a variety of savory dishes in the forms of roasts, sausages, jerk meat, etc.; and

WHEREAS, the U. S. Navy, as well as the Fish and Game Division of the Department of Land and Natural Resources, State of Hawaii, should immediately cease the wasteful killing and inhumane poisoning of goats; and

WHEREAS, a policy for goat hunters or any interested parties should be established and executed between the Mayor and the U. S. Navy, thus establishing a quota system; and

WHEREAS, a strict control on the hunters could be supervised by State, County and military officials; and

WHEREAS, a workable civilian-military public relations policy could be implemented with the Navy supplying transportation and escort; and

WHEREAS, live kids could be supplied as pets for many of Maui's youngsters; and

WHEREAS, a special meeting should be called, inviting the Navy, the Mayor, and the Council and all interested hunters to discuss the aforementioned proposals; now, therefore,

RESOLUTION NO. 241

BE IT RESOLVED by the Council of the County of Maui that it does hereby request the Mayor to hold a special meeting with the Council, the U. S. Navy, and all interested hunters to discuss the possible ways of utilizing the goats on the island of Kahoolawe; and

BE IT FURTHER RESOLVED that certified copies of this resolution be transmitted to the Mayor of the County of Maui and to Rear Admiral Donald Davis, Commandant of the 14th Naval District.

COUNCIL OF THE COUNTY OF MAUI
Wailuku, Hawaii 96793

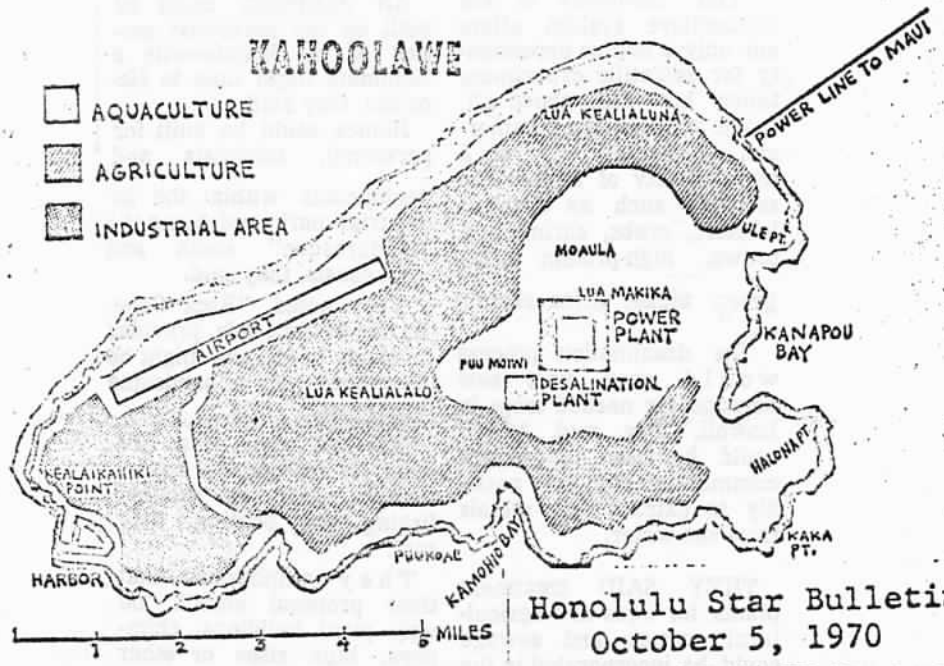
CERTIFICATION OF ADOPTION

It is HEREBY CERTIFIED that the foregoing resolution was adopted by the Council of the County of Mau, State of Hawaii on the 19th day of June, 1970 by the following vote:

County Clerk, County of Maui

Kahoolawe Suggested for Thermonuclear Power Plant

By Helen Altonn
Star-Bulletin Writer



Honolulu Star Bulletin
October 5, 1970

Kahoolawe could be transformed from a Navy bombing target into a world-renowned thermonuclear power and aquaculture development, says a University of Hawaii microbiologist.

Dr. Kaare R. Gundersen has prepared an informal proposal for utilization of Hawaii's smallest Island after two years of research funded by the Hawaiian Electric Co.

Assisting him was Paul K. Bienfang, a student in the honors program.

Their project involved a series of experiments on the fertility of deep water as compared with surface water. This led them to Kahoolawe.

They concluded. "Kahoolawe is the only place in the State — and one of few places in the world — where a major power plant and aquaculture can be economically combined on the principle of common use of deep, cold and nutrient rich ocean water."

"IT'S A SIMPLE thing, basically," Gundersen commented in an interview. "I have discussed it with people knowledgeable in engineering and oceanography and actually there is no point where this would not work."

A central power plant to supply all of Hawaii with electric power is going to be built eventually anyway, he said.

"Our proposal is to make full use of the plant — to make sure no thermal pollution occurs — and to reactivate the old fishpond idea.

"Our research points to Kahoolawe as the only site in Hawaii where such a thing would be extremely feasible, first because of the possibility that Kahoolawe might be obtained for civil use."

THE ISLAND'S 45 square miles are arid and virtually without fresh water thus of little real estate value, he said.

If the federal government should release the area to the State, it probably would be without cost, he continued. So leaseholds could be offered at attractive low fees to the Hawaiian Electric Co., agricultural and aquacultural developers and others interested in related industries, he added.

Gundersen and Bienfang turned their proposal over to a committee formed this summer with representatives of HECO, various State agencies and the University's Institute of Marine Biology.

The researchers said Kahoolawe's characteristics present an opportunity for "an advanced technological project of far-reaching significance, some of which may be used as models for other countries of the world."

The plant could be either thermonuclear or geothermal, they noted, adding that the proposal is based on the use of nuclear power "although the kind used is irrelevant."

SIGNIFICANT features of their proposal include:

—Building the power plant underground on the elevated eastern end of the Island, both for security and aesthetic reasons.

—Statewide distribution of electric power through cables laid on the sea floor along tracks between Islands.

—Piping cooling water into the power plant from the submarine canyon south of Kanohio Bay on the steep, southern side of Kahoolawe.

—Use of the cooling water with its high nutrient contents as a water base for aquaculture after it is released from the power plant.

—Construction of a desalination plant with the power plant, based on distillation of sea water and powered by excess waste heat to produce fresh water to irrigate some 15,000 acres of dry land.

—Development of about 2,000 acres on the western side of the Island into an industrial park with canneries and other plants to process the sea food and agricultural products harvested on the Island.

ELABORATING on the aquaculture and agricultural aspects of the plan, the research team said water from the power plant could be channeled into a system of ponds built along the entire 12-mile-long northwest coastline.

They estimate that about 2,000 acres of ponds could be constructed.

The temperature, salinity and nutrient content of the water in individual ponds could be regulated through the combination of the power plant cooling system and desalination installation, they said.

Honolulu Star Bulletin
October 5, 1970
(continued)

"This flexibility of the aquaculture system offers not only a unique opportunity for scientific experimentation but will, above all, make possible the commercial production . . . of a wide variety of high-priced seafoods such as oysters, lobsters, crabs, shrimp and prawn, high-protein blue-green algae, brine shrimp . . ."

The desalination process would open vast new acreage for needed crops in Hawaii, they said. And it could be used to produce commercial salt and possibly to extract rare metals from sea water.

THEY SAID treatment plants for aqua and agricultural wastes and sewage could be incorporated in the industrial park and be reused as fertilizer rather than be discharged as pollution.

"The possibility also seems to exist of utilizing nuclear heat to operate an incinerator for hard wastes, such as used cars which could be shipped to Kahoolawe from their unsightly graveyards on the other islands and disintegrated," they said.

They point to the research potential of the Kahoolawe development, with laboratories for marine biology, agronomy and related fields.

They recommend that Smuggler Cove (adjacent to the industrial park) be developed as a navigable harbor for ships of any size, adding:

"It is visualized that, possibly, the Hawaiian tuna fleet and other fishing vessels might find this harbor with its modern canning plants more suitable as an operational basis than Kewalo Basin, thus relieving existing conditions in Honolulu."

AN AIRPORT could be built on the northwest section of the Island—with a 30-minute flight time to Honolulu, they said.

Homes could be built for personnel, scientists and technicians within the industrial park and along the "picturesque" south and east coasts, they said.

They noted, "Beck Cove, on the eastern side, provides a sandy beach and might be developed into a handsome beach park."

This and other areas are ideal for recreational opportunities, such as surfing, fishing and boating, they said.

They emphasized that their proposal entails "no ugly plant buildings, chimneys, high rises or other sight-annoying structures—and no kind of environmental pollution will be produced."

With such a development, they added, Kahoolawe "could team with its sister islands and emphatically benefit all of Hawaii."

NOISE SURVEY OF SELECTED AREAS ON THE ISLAND OF MAUI IN CONNECTION WITH HOVERING ON KAHOOLAWE ISLAND 21 MAY 72

Time	Location	Noise Level (dBA)	Remarks
1410	PAPAWAI PT., Maalaea area	48-54	Sunny day, light to moderate NE winds along the shoreline
1430	"	50-56	Bombs can be faintly heard, but do not register on sound level meter. Smoke can be plainly seen. No fibration effects noticed.
1440	"	58-62 63 64	No bombs heard Cars passing Gusty winds
1450			Moved to KIHEI area
1510	Kalama Park, KIHEI	46-50	Shoreline area, light to moderate winds. No bombs seen or heard.
1515	"	65-70	Gusty winds
1530	"	56-64	Windy
1600	"	74	Wind gusts
1700	3 mi. South of Kalama Park	68-74	Windy, no bombs seen or heard
1725	Kamaole Park, 2 mi. South of Kalama Park	74-80	Gusty winds, no bombs seen or heard.
1800	"	78-84	Very gust winds
1815	Maalaea Bay area		Smoke can be seen but bombs cannot be heard
1845	Arrived at Kahului airport for 1915 flight to Honolulu.		

All noise levels recorded were from natural sources, i.e. wind, surf, trees, etc.

Readings taken with 1558-BP General Radio Noise Level Meter.

COPY

HOUSE OF REPRESENTATIVES
SIXTH LEGISLATURE, 1971
STATE OF HAWAII

H. C. R. NO. 64

HOUSE CONCURRENT RESOLUTION

REQUESTING A FEASIBILITY STUDY ON THE ESTABLISHMENT AND CONSTRUCTION OF A NUCLEAR POWER PLANT ON KAHOOLAWE ISLAND, HAWAII.

WHEREAS, fossil fuels or energy sources, such as coal and oil, are finite resources which are rapidly being depleted by increased population growth and increased use of energy as society becomes more automated and industrialized; and

WHEREAS, the combustion of fossil fuels for our energy needs has had a detrimental effect on the environment, contaminating the air with noxious fumes; and

WHEREAS, peaceful uses of the atom, such as in the operation of nuclear power plants, have been employed as an alternative source of energy; and

WHEREAS, in 1968, twenty-six states had constructed or had planned for the construction of nuclear power plants to help meet the energy needs of their residents; and

WHEREAS, experience has shown that the construction of nuclear power plants is complex and costly, requiring detailed study and comprehensive planning, such as in the area of technical manpower supply, and nuclear technology; now, therefore,

BE IT RESOLVED by the House of Representatives of the Sixth Legislature of the State of Hawaii, Regular Session of 1971, the Senate concurring, that the Department of Planning and Economic Development, with the assistance of the College of Engineering and the Environmental Center of the University of Hawaii, be, and is hereby, requested to study the feasibility of the construction of a nuclear power plant on the island of Kahoolawe and to submit a report of such study, including the environmental effects of such a plant and cost estimates, to the Legislature prior to the convening of the Regular Session of 1972; and

LRB 746-748

BE IT FURTHER RESOLVED that duly certified copies of this Concurrent Resolution be transmitted to the Department of Planning and Economic Development and the College of Engineering and the Environmental Center of the University of Hawaii.

OFFERED BY: /s/ Peter S. Iha

and 13 others

MAR 10, 1971

copy

HOUSE OF REPRESENTATIVES
SIXTH LEGISLATURE, 1971
STATE OF HAWAII

H. B. NO. 665

A BILL FOR AN ACT

MAKING AN APPROPRIATION FOR A STUDY OF NEW ENERGY SOURCES FOR THE STATE OF HAWAII

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF HAWAII:

SECTION 1. Purpose. Man has developed a technological society in order to achieve control over his surroundings and exploit them for his gain. Synonymous with this quest has been man's consumption of energy, usually in the form of electrical energy from coal or petroleum fuels. In order for man to survive this century, some changes in his life-style and his waste disposal habits are mandatory. His insistence on more energy and power while he refuses to face up to positive action on his concomitant pollution can destroy earth's finite natural resources. In the context of energy utilization, man must either reduce the pollution from present conventional sources, or create access to less polluting sources. The study proposed in this bill would aid in developing new energy sources for the State of Hawaii. It is intended that the initial emphasis shall be concentrated upon the technological and economic factors of various energy sources, with subsequent and increasing attention to the social and environmental considerations as the otherwise most feasible and competitive systems become apparent.

SECTION 2. There is appropriated out of the general revenues of the State of Hawaii, the sum of $275,000 or so much thereof as may be necessary, to the University of Hawaii for a study of new energy sources for the State of Hawaii.

SECTION 3. This Act shall take effect upon its approval.

INTRODUCED BY /s/ Tadao Beppu

FEB 16, 1971

BIBLIOGRAPHY

ALLEN, W. F.
1858. (unpub.) Letter dated May 31, to Messrs. Wyllie and Allen, describing Kahoolawe (original in Archives of Hawaii). Published 1938 in: Paradise of Pacific 50(5): 22,27.

ANON.,
1858. "Kahoolawe - Lease Sold at Auction." Polynesian. April 3, p. 381.

——— 1876. "Kalakaua visits Kahoolawe." Pacific Commercial Advertiser. Jan 1, p. 3.

——— 1881. "Kahoolawe." Hawaiian Gazette. Aug 17, p. 3.

——— 1912. "Kahoolawe the Island that is Wearing Out." Pacific Commercial Advertiser, Jan 14, p. 1.

——— 1912. "Report of the Board of Commissioners of Agriculture and Forestry of the Territory of Hawaii for the Biennial Period ending Dec 31, 1912." Board of Agriculture and Forestry. Honolulu, Hawaii.

——— 1967. "Hawaii's Birds." Hawaii Audubon Society. Honolulu.

——— 1971a "Sportsmen's Calendar." State of Hawaii, Department of Land and Natural Resources Division of Fish and Game. Honolulu.

——— 1971b "State of Hawaii Data Book." State of Hawaii, Department of Planning and Economic Development. Honolulu.

——— 1971c "1969-1970 Report to the Governor." State of Hawaii, Department of Land and Natural Resources. Honolulu.

ARAGO, J.
1825. "Voyage autour du Monde." Paris.

ASHDOWN, INEZ
1947. "A Review of an Island's Destiny of Sorrow." Paradise of the Pacific 59(12): 47-48.

BRYAN, E. H. Jr.
1935. "Kahoolawe, Island of Dust." Hawaiian Nature Notes. Honolulu, p. 52-56.

CAUM, E. L.
1933. "The Exotic Birds of Hawaii." B. P. Bishop Museum Occasional Papers Vol. X No. 9. Published by the Museum. Honolulu, Hawaii.

COOK, J. A.
1784. "A Voyage to the Pacific Ocean in the Years 1776, 1777, 1778, 1779, and 1780." (Third Voyage) 3 Vols. London.

ELLIS, W.
1963. "Journal of William Ellis." Advertiser Publishing Company, Ltd. Honolulu.

FORNANDER, A.
1878. "The Polynesian Race." Vol. 2. London.

FRANCK, H. A.
1937. "Roaming in Hawaii." New York. Stokes.

FORBES, C. N.
1913. "Notes on the Flora of Kahoolawe and Molokini." B. P. Bishop Museum Occasional Papers Vol. V No. 3. Published by the Museum. Honolulu, Hawaii.

HOLLINGSWORTH, LOUISE
1938. "The Kahoolawe Boom of 80 Years Ago." Honolulu Star-Bulletin. July 16. Feature Section. p. 1.

JUDD, C. S.
1916. "Kahoolawe. Hawaiian Annual for 1917." Thrum. Honolulu. pp. 117-125.

JUDD, H. P.
1938. "A Visit to Kahoolawe." Paradise Pacific 50(10): 11-12.

LAMOREUX, C. H.
1970. "Plants Recorded from Kahoolawe." Hawaiian Botanical Society Newsletter Vol. IX Nos. 1-3. June, p. 6-11.

LEBARRON, R. and R. WALKER
1970. (unpub.) "Kahoolawe, A Badly Abused Island - How to Rehabilitate It." (on file - Division of Forestry - Honolulu).

MALO, D.
1903. "Hawaiian Antiquities." B. P. Bishop Museum Special Pub. No. 2. Published by the Museum. Honolulu, Hawaii.

MCALLISTER, J. G.
1933. "Archeology of Kahoolawe." B. P. Bishop. Museum Bulletin 115. Published by the Museum. Honolulu, Hawaii.

MOBERLY, R. M.
1964. "Hawaiian Beach System, Final Report by Ralph Moberly and Theodore Chamberlain." University of Hawaii, Inst. of Geophysics. Honolulu, Hawaii.

MORRIS, P. C.
1934. "How the Territory of Hawaii Grew, and What Domain it Cover." Forty - Second Annual Report of the Hawaiian Historical Society for the year 1933. Honolulu, Hawaii, p. 15-16.

MUNRO, G. C.
1944. "Birds of Hawaii." Tongg. Publishing Company Honolulu, Hawaii.

MYHRE, SHEILA B.
1970. "Kahoolawe." Hawaiian Botanical Society Newletter. Vol. IX No. 4. October, p. 21-27.

RESTARICK, H. B.
1931. "Adventurer Perkins Finds Kahoolawe Desolate, Maui Hospitable, in 1850." Honolulu Star - Bulletin, Feb. 21.

ROCK, J. F.
1913. "Indigenous Trees of the Hawaiian Islands." Published Under Patronage, Honolulu. 518 pps.

STEARNS, H. T.
1940. "Geology and Ground Water Resources of Lanai and Kahoolawe." Division of Hydrography. Territory of Hawaii Bulletin No. 6, in coop. with the Geological Survey U. S. Department of Int. Printed in the Territory of Hawaii.

THRUM, T. G.
1902. "Kahoolawe, an Early Place of Banishment." Hawaiian Annual for 1903. Honolulu, p. 117.

TOMICH, P. Q.
1969. "Mammals in Hawaii." B. P. Bishop Museum Published 57. Bishop Museum Press. Honolulu.

WHITESELL, C. D., D. N. PALMER and H. K. YANAMURA
1971a "Study Plan and Establishment Report for Vegetation Trials for Rehabilitating Kahoolawe Island, Hawaii and Addendum No. 1, Grass and Legume Plantings on Kahoolawe." U.S.D.A. - U. S. Forest Service (Inst. of Pac. Islands Forestry), U. S. Soil Conservation Service and Hawaii Department of Land and Natural Resources.

WHITESELL, C. D., D. N. PALMER and H. K. YANAMURA
1971b "First Progress Report on Vegetation Trials for Rehabilitating Kahoolawe Island, Hawaii.and Appendix 1. First Interim Evaluation of Grass and Legume Plantings on Kahoolawe." U.S.D.A. - U. S. Forest Service (Inst. of Pac. Islands Forestry), U. S. Soil Conservation Service and Hawaii Department of Land and Natural Resources.

APPENDIX M

AGENCY COMMENTS

OFFICE OF THE SECRETARY OF TRANSPORTATION
WASHINGTON, D.C. 20590

ASSISTANT SECRETARY

DEC 2 1971

Mr. D. F. Welch
Assistant Deputy Chief of Naval
Operations (Logistics)
Department of the Navy
Washington, D.C. 20350

Dear Mr. Welch:

We appreciate the opportunity to review and comment on this draft environmental impact statement for Kahoolawe Island Target Complex Hawaiian Archipelago. We have no specific comments to offer on the statement.

We look forward to receiving the final environmental impact statement, including the comments received from other public agencies and the general public on the draft statement.

Sincerely,

John E. Hirten
Deputy Assistant Secretary for
Environment and Urban Systems

ADVISORY COUNCIL
ON
HISTORIC PRESERVATION

WASHINGTON, D.C. 20240

November 11, 1971

Dear Admiral Welch:

This is in response to your request for comments on the environmental impact statement identified by a copy of your cover letter attached to this document. The staff of the Advisory Council has reviewed the submitted impact statement and suggests the following, identified by checkmark on this form:

___ The final statement should contain (1) a sentence indicating that the National Register of Historic Places has been consulted and that no National Register properties will be affected by the project, or (2) a listing of the properties to be affected, an analysis of the nature of the effects, a discussion of the ways in which the effects were taken into account, and an account of steps taken to assure compliance with Section 106 of the National Historic Preservation Act of 1966 (80 Stat. 915) in accordance with procedures of the Advisory Council on Historic Preservation as they appear in the Federal Register, February 20, 1971.

✓ In the case of properties under the control or jurisdiction of the United States Government, the statement should include a discussion of steps taken to comply with Section 2(b) of Executive Order 11593 of May 13, 1971.

___ The final statement should contain evidence of contact with the Historic Preservation Officer for the State involved and a copy of his comments concerning the effect of the undertaking upon historical and archeological resources.

___ Specific comments attached.

Comments on environmental impact statements are not to be considered as comments of the Advisory Council in Section 106 matters.

Sincerely yours,

Robert R. Garvey, Jr.

Robert R. Garvey, Jr.
Executive Secretary

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

JAN 3 1 1972

Dear Admiral Welch:

We have reviewed the draft environmental statement on the Kahoolawe Island Target Complex, Hawaii, as requested in your letter of November 5, 1971. It is generally speaking a very creditable job of environmental examination and study. The comments we have relate primarily to improving the statement in several technical areas.

Historical and Archeological Resources

We recognize that the island has provided a target complex for military use for some thirty years. However, as a matter of proper project analysis and in view of the fact that historic sites and ruins remain on the island and in the target area, consultation with the National Register, through the State Liaison Officer, should be shown in the statement. Likewise some evidence of consultation with the State Archeologist regarding archeological resources is desirable. Should any real significant resources be found involved, it would seem likely that some at least might be accommodated by target movement.

Erosion

Although a greater part of the island seems to suffer more from goats and sheep than ordnance, considering the armaments and tonnages involved and the concentrated target area, the impact of land surface disturbance is treated rather lightly in discussing erosion effects. Cratering, blast and fire will keep some of the area exposed in raw soil condition rather steadily and inhibit ground cover establishment. Erosion would tend to be more accelerated than without such munitions impact.

The estimated impact area (1113.5 acres) implies precision about the extent of surface disturbance that is questionable. The central part of the island should simply be acknowledged as heavily disturbed and subject to somewhat greater than normal erosion.

Comparison of the 1931 and 1970 maps for erosion area changes is rather inconclusive, perhaps due to sketchiness of the maps. It is clear that a large part of the island is still considered eroded.

Beneficial Effects
While technically correct, the beneficial effects claimed here from military use might be better acknowledged as slight (p. 15). Continued use of the island as a target area makes these benefits somewhat irrelevant.

Irretrievable Resources
Resources not included in this section and which should be discussed also include; feral animals killed, other wildlife destroyed, and marine resources destroyed. Although some of the resources are slight, they are nevertheless irretrievable.

Vegetative Growth
Assessment of the increased spread of vegetative growth attributed to military control, largely through removal of feral animals, somewhat ignores the beneficial results of fencing off part of the island before military control and other actions of private ownership between 1931-41 (p. F-1). This is not intended to minimize the effective actions of the Navy. In fact the extensive nature of Navy control activity might be brought out even more sharply under the Beneficial Effects section.

The conclusion that the soil structures are incapable of productive capacity of commercial value (p. 30, par. 2) might be qualified dependent upon completion of the experimental plantings underway.

We thank you for the opportunity to review this statement and hope our comments prove useful in developing a final environmental impact statement.

Sincerely yours,

(sgd) W. W. Lyons

Deputy Assistant Secretary of the Interior

Rear Admiral D. F. Welch
Assistant Deputy Chief of
Naval Operations (Logistics)
Office of the Chief of Naval
Operations
Department of the Navy
Washington, D. C. 20350

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
REGION IX
100 CALIFORNIA STREET
SAN FRANCISCO, CALIFORNIA 94111

JAN 4 1972

Office of the Chief of Naval Operations
Department of the Navy
Washington D. C. 20350

Dear Sir:

We are replying to your letter of November 5, 1971 requesting our review and comment on the draft environmental statement for the Kahoolawe Island Target Complex, Hawaiian Archipelago.

The impact of this project on the environment is an important concern; however, appropriate considerations have not been fully covered in the statement. Specific comments are enclosed.

We believe, if you consider these comments in revising the text of your statement, it will result in a more complete and meaningful evalation of the project's environmental impact. We would appreciate receiving a copy of your final statement.

Sincerely,

Paul DeFalco

Regional Administrator

Enclosure

Environmental Protection Agency
Region IX

Review and comment on the draft Environmental Impact Statement submitted by the Department of the Navy for the Kahoolawe Island Target Complex, Hawaiian Archipelago.

The statement addresses a project that is particularly environmentally destructive. The principal military function of high explosives is environmental destruction. Despite the magnitude of this action, the continued use of this island as a target complex will probably not involve lands in addition to those currently in use, and will probably not increase the damage already done. As the area does not constitute an inhabited part of the human environment, the majority of the necessary considerations focus on future uses of Kahoolawe and influence on biological systems. There are several items in the statement that should be clarified; these items are discussed below.

This statement could be improved substantially by addressing a section to the water pollution problems of the Island. The problems of erosion, siltation and chemical contamination of the ocean and tidelands around the island should be discussed in more detail.

The presence of undetonated ordnance on the shoreline should be considered. The hazards of such devices should be explained. Their potential for coastal water pollution, wildlife damage, and other environmental effects should be discussed.

The status of affected archeological sites should be determined. The statement indicates that four sites are within 500 yards of the target area. If these areas are still intact, then they assume more importance than if they have already been damaged or destroyed. This should be discussed in the final statement.

The potentials for air and water pollution should be discussed in more detail. Bi-products of the ordnance used should be discussed more specifically. Those chemicals that may contribute to pollution should be considered relative to concentrations and probable effects that they will have on biological systems. The statement notes that airborn dust has been deposited on Maui, but does not consider air pollution from Kahoolawe to be a problem. This conflict should be resolved in the final statement.

Alternatives need more consideration, since their impacts are substantially different from the described project. Although exhaustive analyses are not expected, some indication of the type and magnitude of impact should be included to further

define the environmental alternatives. The prospects for nuclear or geothermal power generation on the island should be dealt with in more detail. The geothermal alternate was only briefly discussed. The sources, methods, wastes, and hazards of such activity need to be defined and discussed. Nuclear power generation should be discussed in more detail, especially in terms of seismic hazards, thermal pollution, and waste disposal. The activities proposed to accompany the power plant (desalinization and aquaculture) should be discussed relative to their estimated impacts. In order for the alternatives to be weighed against the continued use of the island for target purposes, these impacts must be studied and evaluated.

Animal and plant surveys indicate terrestrial forms, but do not discuss shore or adjacent marine organisms. These should be inventoried for several reasons, 1) these areas have experienced some target activity, 2) unexploded ordnance has been identified in these areas, 3) these areas are the most likely to be used for any possible future recreational or commercial development, and 4) these organisms will probably be most affected by water pollution resulting from military use of Kahoolawe.

APPENDIX N

DISPOSITION OF AGENCY COMMENTS

Disposition of Agency Comments

A. Department of Transportation ltr of 2 December 1971

(1) No reply required.

B. Advisory Council on Historical Preservation ltr of 11 November 1971

Comment

In the case of properties under the control or jurisdiction of the United States Government, the statement should include a discussion of steps taken to comply with Section 2(b) of Executive Order 11593 of May 13, 1971.

Reply

It is our plan, based on a recent meeting with Department of the Interior on implementing the subject Executive Order, that the three services will initially formulate a list of facilities/activities that are at least 50 years old. This list will in turn be forwarded to Interior for review and transmitted to the State level for coordination and authentication. The Naval Facilities Engineering Command is preparing the Navy input with a submission date planned for early 1972.

C. Environmental Protection Agency; Region X, ltr of 4 January 1972

Comment

This statement could be improved substantially by addressing a section to the water pollution problems of the Island. The problems of erosion, siltation and chemical contamination of the ocean and tidelands around the island should be discussed in more detail.

Reply

Concerning the question of contamination of target-island soil, and eventually the tidelands and ocean around the island due to naval gunfire, information is not available on which to base precise quantitative statements. It is possible, however, to provide approximate answers as follows:

1. Explosives decomposition products to be expected from projectile detonations include carbon (as a solid), carbon monoxide, carbon dioxide, water, nitrogen, hydrogen, methane, hydrocyanic acid and oxides of nitrogen (all as gases). The latter 3 types of materials will appear only in very small quantities, if at all.

2. Almost all (probably more than 99%) of the projectiles that detonate do so before or upon impact with the ground due to fuzing. Even for worst case conditions (projectile buried at time of detonation), it may be expected that less than 1% of the gases produced would be retained in the soil.

3. Carbon is the only one of the above substances noted that might persist in the soil for more than a few days or weeks. All others are subject to dissipation as gases or due to chemical reaction with oxygen and soil minerals to form water-soluble products that rainfall eventually will remove. The oxides of nitrogen, for instance, will form soluble nitrites and nitrates and duplicate those compounds found normally in nature. There is no doubt that some silting will subsequently occur but the contribution of either silting or water pollution due to naval gunfire is considered minimal to natural erosion occuring because of natural forces.

Comment

The presence of undetonated ordnance on the shoreline should be considered. The hazards of such devices should be explained. Their potential for coastal water pollution, wildlife damage, and other environmental effects should be discussed.

Reply

A survey was completed by Commander, Underwater Ordnance Demolition Group Pacific in May of 1969 and the presence (in unspecified amounts) of undetonated ordnance in the tidal zone and out to the 10 fathom curve was confirmed. It is to be noted that since 1941 the island has been utilized by a target, by both Army and naval units, with practically no records kept on ordnance removal accomplished until recent years. Accordingly, it must be assumed that a hazard exists and by the same token this is one of the reasons the island is considered a restricted zone. Only when sanitation of Kahoolawe becomes a real and operational problem can the real hazard be addressed but there is no doubt but that removal of the undetonated ordnance poses a costly and time consuming project. As for the potential for coastal pollution and wildlife damage, it can only be assumed to be minimal as marine life seemingly exists undeterred in the offshore areas and local fishing has been permitted from time to time.

Comment

The status of affected archeological sites should be determined. The statement indicates that four sites are within 500 yards of the target area. If these areas are still intact, then they assume more importance than if they have already been damaged or destroyed. This should be discussed in the final statement.

Reply

It is to be noted that the 50-odd archeological remains described by McAllister, which included questionable but prospective sites such as piles of stones, etc. were stated as being on the island in 1933 or long before the heaviest use period at a target. The location of the 4 sites (less than 500 yards from a target) noted was accomplished by comparing McAllister's original work with the island as appears today and not from direct observation. Personal contact with individuals who have visited the island do not recall any structures, etc., which resemble archeological remains existing today near the target areas in question although it must be stated that these individuals are not necessarily trained observers and could have been mistaken. The Navy has been envolved with the Department of Interior in taking the initial steps of complying with Section 2(b) of Executive Order 11593 of May 13, 1971 which will eventually list and promote selection of historical sites for preservation.

Comment

Alternatives need more consideration, since their impacts are substantially different from the described project. Although exhaustive analyses are not expected, some indication of the type and magnitude of impact should be included to further define the environmental alternatives. The prospects for nuclear or geothermal power generation on the island should be dealt with in more detail. The geothermal alternate was only briefly discussed. The sources, methods, wastes, and hazards of such activity need to be defined and discussed. Nuclear power generation should be discussed in more detail, especially in terms of seismic hazards, thermal pollution, and waste disposal. The activities proposed to accompany the power plant (desalinization and aquaculture) should be discussed relative to their estimated impacts. In order for the alternatives to be weighed against the continued use of the island for target purposes, these impacts must be studied and evaluated.

Reply

Although the alternative use of Kahoolawe as the site of a thermonuclear power plant was presented in the Draft Statement it must be kept in mind that this is not a proposal of the Navy and accordingly detailed discussion of this alternative must originate with that jurisdiction having the basic requirement. It is noted that studies had been completed by the Hawaiian electric Company and requirements/procedures do exist for preparation of Environmental Impact Statements upon application for the necessary Atomic Energy Commission permits. Accordingly, further information in this regard will naturally await the submission of a decision on the part of the local utility. The specific alternatives available to the Navy for use of Kahoolawe

as a target are discussed in the Draft Statement and admittingly are considered impractical when past use of the island as a target is considered.

Comment

Animal and plant surveys indicate terrestrial forms, but do not discuss shore or adjacent marine organisms. These should be inventoried for several reasons: (1) these areas have experienced some target activity; (2) unexploded ordnance has been identified in these areas; (3) therse areas are the most likely to be used for any possible future recreational or commercial development; and (4) these organisms will probably be most affected by water pollution resulting from military use of Kahoolawe.

Reply

With notable exception of Beck Cove on the western end of the island, beaches are rare along the southern and western sides where the sheer cliffs drop into deep water. The beach at Smuggler Cove is large enough to include sand dunes. Typical strand flora for the Hawaiian islands has been reported: Scaevola frutescens, Boerhavia diffusa, Capparis sandwichiana, Lipochaeta bryani, Jacquemontia sanwichensis, and Ipomoea (sp.). Although not specifically reported, ghost crabs (ocypode ceratophthalma) and other sand dwellers normally inhabit these strands. The rocky shores abound with grapsid and xanthid crabs also with opihi (Helcioniscus argentatus and H. exaratus). These latter are limpets and are sold in local markets as a Hawaiian delicacy. Their abundance on Kahoolawe is undoubtedly due to the restricted status of that island. In 1969, the State Division of Fish and Game made a controlled collection of opihi in the Smuggler Cove area. Two men collected 3 gals. (with shell) of opihi in 3 hours, or 0.5 gals. per manhour. The size of the limpets (2"-3" shell diameter) was generally larger than those normally sold in Honolulu markets. On this same survey, controlled thrownet casts were made and a fish transect was run. In 3 hours of thrownetting a total of 69 fish were caught: 50 aholehole (Kuhlia sandvicensis), 10 moi (Polydactylus sexfilis), 5 kupipi (Abudefduf sordidus), 3 nenue (Kyphosus cinerascens), and 1 surf maiko (Acanthurus nigroris). The fish were large and relatively easy to catch with a thrownet. Both this fact and the presence of aholehole and moi are indicative of the relatively unfished status of the Smuggler Cove area. The density and diversity of reef fish in this cove has been described as greater than that at Hanauma Bay on Oahu, a state park where all fishing is prohibited. Smuggler Cove receives relatively higher fishing pressure than the remainder of Kahoolawe; thus even better fish stands may be implied. During the fish transect 54 different species were sighted. The density was estimated at 1,668 pounds per acre. Considered by species, the fish were unusually large. They were also relatively unconcerned by the presence of divers in the water. Some of the specific density estimates were: weke (Mulloidichthys samoensis)

301 lbs/acre, uhu (Scarus perspicillatus) 296 lbs/acre, ulua (Carangoides gjax) 266 lbs/acre, maiko (Acanthurus leucopareius) 145 lbs/acre. The bottom was sandy with numerous patches of coral (Porites lobata, P. spp., Pocillopora meandrina, and Montipora spp.). The area from Smuggler Cove to beyond the restricted zone on Kuia Shoal has been described as one of the most beautiful diving areas in the Hawaiian chain. At about 200 ft. depth on Kuia Shoal, the bottom consists of basaltic outcroppings interspersed with sand bottom. Large and beautiful corals grow on these outcroppings. There are many excellent beds of precious black coral (Antipathes grandis) in this area; also the precious pink coral (Corallium secundum) is known to exist here. The coral heads and patch reefs in this and other locations about Kahoolawe are undoubtedly sources of coral sand for the small beaches on the northern and western shores of the island. Also sighted in the Smuggler Cove area were spiny lobster (both Panulirus japonicus and P. penicillatus must exist here), a turtle (Chelonia mydas), an octopus (Polypus sp.), and a manta ray (Manta alfredi?). Due to the relatively unfished status of Kahoolawe, spiny lobsters, octopus, and probably Kona crab (Ranina ranina) should exist in abundance. Many of the larger gastropods sought after by shell collectors (such as Conus literatus, C. cingulum, Harpa conoidalis, Charonia tritonis, Cassis spp., Turbo spp., Terebra spp., and others) should be present since the area is reported excellent for shell hunting. A school of 20 to 30 spinner porpoises (Stenella sp.) are often sighted in the waters near Kahoolawe. The sighting of a green sea turtle (Chelonia mydas) in Smuggler Cove suggests that the small beaches along the shore could possibly be used for nesting.

Fishing off the southern and eastern shores of Kahoolawe is reported excellent. Here the cliffs drop straight into the ocean and the water is relatively deep. With Beck Cove as a notable exception, beaches are rare along the rocky shores. Just outside the restricted zone fishing for red snappers, especially opaka (Pristipomoides microlepis) and onaga (Etelis carbunculus) is reported as excellent. The take of ono (Acanthocybium solandri) is very good. This fish is a bank dwelling fish which is sensitive to heavy fishing pressure due to its limited habitat. The excellent fishing in this area probably is a result of the restricted status of the waters about Kahoolawe. The area is also reported as extremely good for kahala (Seriola dumerilii), uku (Aprion virescens), and the various tuna (Thunnus albacares, Euthynnus affinis, and Katsuwonus pelamis). It is not, however, much used by marlin fisherman. Many grey sharks (Carcharhinus sp.) and some tiger sharks (Galeocerdo cuvieri) are also found in these waters. At about 600 ft. depth, good hauls of deep water shrimp (Heterocarpus ensifer and H. laevigatus) have been taken.

Humpback whales (Megaptera novaeangliae) are frequently seen about Kahoolawe from January to April. It is important to note that the various channels between Maui, Molokai, Lanai, and Kahoolawe are reputed to be spawning and calving grounds for this species.

As may be seen from the above discussion, the marine life surrounding Kahoolawe has been relatively unaffected by the military use of the island, and with the impact considered far less in the future than past occurences, it may be assumed that little if any future effect will be noticeable.

D. Department of the Interior ltr of 3 January 1972

Comment

We recognize that the island has provided a target complex for military use for some thirty years. However, as a matter of proper project analysis and in view of the fact that historic sites and ruins remain on the island and in the target area, consultation with the National Register, through the State Liaison Officer, should be shown in the statement. Likewise some evidence of consultation with the State Archeologist regarding archeological resources is desirable. Should any real significant resources be found involved, it would seem likely that some at least might be accommodated by target movement.

Reply

See comment to item B, page N-1 and to item C page N-3.

Comment

Although a greater part of the island seems to suffer more from goats and sheep than ordnance, considering the armaments and tonnages involved and the concentrated target area, the impact of land surface disturbance is treated rather lightly in discussing erosion effects. Cratering, blast and fire will keep some of the area exposed in raw soil condition rather steadily and inhibit ground cover establishment. Erosion would tend to be more accelerated than without such munitions impact.

Reply

It is admitted, all effects being considered equal, that erosion would probably be accelerated in target impact areas. This is an adverse environmental effect that cannot be avoided in the use of Kahoolawe Island as a military target.

Comment

The estimated impact area (1113.5 acres) implies precision about the extent of surface disturbance that is questionable. The central part of the island should simply be acknowledged

as heavily disturbed and subject to somewhat greater than normal erosion.

Reply

Concur; the acreage mentioned for estimated impact area was merely cited to illustrate that portion of the total acreage (28,000 acres) affected.

Comment

Comparison of the 1931 and 1970 maps for erosion area changes is rather inconclusive, perhaps due to sketchiness of the maps. It is clear that a large part of the island is still considered eroded.

Reply

Concur, the maps do leave something to be desired and in addition high and persistent winds caused by the deflection of the trades over and around Haleakala (the 10,000 ft. volcano on Maui) are characteristic of Kahoolawe. In consequence, all erosion is aeolian; the good agricultural soils reputed to have existed on the central plateau in the 1850s have been stripped away by the winds. Soil loss was initiated in the 1900s by overgrazing, principally by sheep and goats, a problem that has persisted to the present time.

Comment

While technically correct, the beneficial effects claimed here from military use might be better acknowledged as slight (p. 15). Continued use of the island as a target area makes these benefits somewhat irrelevant.

Reply

Concur.

Comment

Resources not included in this section and which should be discussed also include; feral animals killed, other wildlife destroyed, and marine resources destroyed. Although some of the resources are slight, they are nevertheless irretrievable.

Reply

Concur; however, presence of these resources on Kahoolawe do not indicate an irrevocable loss and populations appear to be abundant.

Comment

Assessment of the increased spread of vegetative growth attributed to military control, largely through removal of feral animals, somewhat ignores the beneficial results of fencing off part of the island before military control and other actions of private ownership between 1931-41 (p. F-1). This is not intended to minimize the effective actions of the Navy. In fact the extensive nature of Navy control activity might be brought out even more sharply under the Beneficial Effects section.

Reply

Present content of Beneficial Effects section is considered adequate.

Comment

The conclusion that the soil structures are incapable of productive capacity of commercial value (p. 30, par. 2) might be qualified dependent upon completion of the experimental plantings underway.

Reply

The conclusion reached as to the productive capacity of agriculture on Kahoolawe was merely indicative of past efforts to turn a profit and in comparison with the more productive areas of the islands. It is possible that erosion can be retarded somewhat by the introduction of plantings but it is not proposed that the island can eventually support commercial exploitation.