

THE RABBITS OF SANTA BARBARA ISLAND

A Progress Report and Summary

by Lowell Sumner, Biologist
Sequoia & Kings Canyon National Parks
June 15, 1958

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Transcribed by Rachael Willie

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BEFORE AND AFTER

1950

Fig.1. In 1950, the tree sunflowers had a luxuriant understory - and no rabbits.

1954

Fig.2. In 1954, the understory was gone -- eaten up -- and the bare ground beneath the stricken Sunflowers was almost completely covered by rabbit pellets.



1. Introduction

In 1954 an outbreak of feral rabbits on Santa Barbara Island of the Channel Islands National Monument reached such enormously destructive proportions that the National Park Service asked for the assistance of the U.S. Fish and Wildlife Service and the California Department of Fish and Game in controlling the outbreak. Important logistic support also was obtained subsequently from the U.S. Coast Guard.

A primary purpose of the present report is to record the progress in the control that was made possible through the generous assistance of these agencies, and to express to them the deep appreciation of the National Park Service for their unfailing support.

An additional purpose is to underscore the urgent need on Santa Barbara Island not only for completion of the rabbit removal program but for establishment of an expanded program of basic ecological research to more fully determine and record the fascinating and continually changing ecological history of the island. This ecological history, so far largely neglected, is basic to the interpretive story of Channel Islands National Monument and to ecological studies of other areas both within and beyond the confines of the National Park System.

2. Acknowledgements

Special thanks are due to former District Agent H. Nelson Elliott, now in charge of predatory animal and rodent control operations in the Regional Office of the Fish and Wildlife Service, Portland, and to his able assistants and field men, particularly Maynard W. Cummings (now in Colorado), Warren D. Bloys, Albert Traub, and Eric Peacock. These men provided not only the technical advice and assistance necessary for the control operations but gave freely of their interest, time and energy beyond the call of duty during frequent visits to the island.

Special thanks go also to Deputy Director Walter T. Shannon, California Department of Fish and Game, Sacramento, and to Wildlife Protection Supervisor (Marine) T.W. Schilling, Terminal Island, for the many occasions on which they have made available the patrol vessel "Bluefin" for transporting the interagency field parties between the island and the mainland. Our thanks go also to Captain Don DeSpain of the "Bluefin" and to his skilled crew for their unfailing courtesy and their ability to land our parties on Santa Barbara Island's rugged and difficult shore under all weather conditions encountered.

Deep appreciation is extended to the Commanding Officer in charge of the Coast Guard air station at San Diego who, by arrangement with Superintendent Don Robinson, Cabrillo and Channel Islands National Monuments, had several hundred pounds of control materials air-dropped to our field parties during their operations.

National Park Service personnel who have participated in the control programs have been too numerous to list in full, but Park Ranger Robert Grom of Cabrillo National Monument deserves special mention because of his efficient assistance and his special interest in all island wildlife, displayed over a period of years.

3. Description of the Island

Physical Features. Santa Barbara Island is a roughly triangular plateau of 638 acres bounded virtually on all sides by high volcanic cliffs which rise abruptly from the boiling surf. The island affords three contrasting major habitats; (1) the surrounding under water marine gardens and kelp forests, insufficiently explored as yet but with a high future recreation potential, (2) the sea cliffs and ledges with their great throngs of sea lions, occasional sea elephants, and thousands of nesting pelicans and cormorants, where the booming of the surf mingles everlastingly with the cries of marine birds and mammals, (3) the flower-covered plateau top, quiet and remote, with its unique assemblage of plants and small songbirds, some of which have been isolated from the mainland since the Pleistocene Age.

The Giant Coreopsis. The plateau top is the habitat that has been drastically affected by the introduced rabbits. It contains the world's largest remaining stand of Giant Coreopsis or "Tree Sunflower" (*Coreopsis gigantea*). This is the most spectacular of the island's many unique plants. With an individual life span apparently sometimes exceeding ten years, this relic of a bygone era, like many modern plants of the Southern California mainland, enters a period of dormancy at the onset of the long, dry summer season. Its leaves shrivel, and droop like miniature palm fronds from the stubby, gray-barked, pre-historic looking trunks. But with the coming of the winter rains new feathery fronds push out from all the branches, interlocking and forming, under favorable conditions, an almost impenetrable jungle, head-high and vividly green.

Then in April the crown of each "tree" becomes an almost solid canopy of closely spaced golden-yellow flowers of a brilliance that must be personally experienced to be fully appreciated, causing large areas of the island to gleam brilliantly when sighted from ships at distances of several miles out to sea.

Other Plants. At this time of year lesser plants in great variety also form carpets of blue, white, and gold, rivaling the best displays that the desert has to offer, while the delicate white trumpets of the giant morning glory, an exclusively island race, clothe the walls of the ravines and festoon the trunks and branches of the *Coreopsis*.

Birds. Such a profusion of plants, of which 82 species have been recorded so far for the island, naturally has made possible a comparatively abundant and diversified bird population, at least until the introduction of the rabbits. Likewise, the ups and downs of the plant environment have caused striking ups and downs in the bird world, as indicated below.

The Santa Barbara Island Song Sparrow is largely confined to the *Coreopsis* "jungle", or what remains of it, and has not been recorded anywhere are strictly island birds that occur on various other Channel Islands as well.

4. Shifting Tides of Survival

A. Before NPS Protection

Prehistoric Isolation. So long have the Channel Islands been isolated from the mainland, that their plant life has never become adapted to withstand the presence of grazing and browsing animals, or even of rodents larger than a mouse. In fact ecologists believe that some of the unique and sensitive plant types now present could not have evolved into what they are in the presence of such animals. Thus for uncounted centuries the island plants flourished abundantly and uneventfully in their small, remote world.

Man Arrives. Then about one hundred years ago the white man came with his domestic animals and brought violent and changing ecological conflict. Santa Barbara Island's virtual lack of fresh water except during winter rains undoubtedly protected it from some of the more intensive and radical types of human use that were inflicted on the native plants of other Channel Islands. However prior to the drier climatic conditions that have prevailed over Southern California during the last 15 years there was "a small seepage on one of the eastern bluffs" (Dunkle, p.270) and this seep was noted as late as 1941 by Park Ranger Clarence Fry, though it has definitely been absent at least since 1950.

Goats. At any event moisture conditions in the earlier years were sufficiently favorable that the island could become densely populated by goats prior to 1857. (Dunkle, p.261). The lack of subsequent records indicates that they did not prosper, but the demonstrated liking that goats have for the tree sunflower forces us to conclude that the latter must have been nearly exterminated before the goats died out or were removed. Likewise the Song Sparrows must have been in precarious straits.

Temporary recovery from the goats evidently took place, however, for in 1863 one of the earliest scientific expeditions to the area found the soft soil of the level portions with their burrows. But again the pendulum started its swing in the direction of destruction of original conditions.

House Cats. Continued use of the island as a base for sea otter hunting and lobster fishing resulted in the introduction of house cats, no doubt by various fishermen in an effort to rid their shacks of the abundant Island Mouse, a species restricted to the islands.

The cats failed to get rid of the Island Mouse but apparently they exterminated the nesting colonies of the auklets by 1908 (Howell, p.21). These colonies have never reappeared, nor have the sea otters (except for a rare straggler), which also were virtually exterminated during the early years.

Farming. In 1918 Santa Barbara Island was burned over to clear the level area, once used by the auklets, for farming. Rusted remnants of an old fashioned horse-powered hay press, a harrow, hay rake, and other farm implements and the skeletons of two horses remain as slowly disintegrating relics of this era and have been gradually transformed by the passage of time into historic objects. Apparently various individuals tried their hand at farming and sheepraising even before 1918, and such sporadic attempts continued until a year or two before the Lighthouse Service transferred the island to the National Park Service in 1938.

When the writer first visited the area in 1939 evidences of human occupancy among the fisherman's shacks was quite recent. At least one of the three cement cisterns constructed by the "farmers" had several feet of water in it at that time, and probably they all did, for conditions in 1938 were markedly less arid than in subsequent years. But the *Coreopsis* in the unfarmed areas was at that time much more luxuriant than later, for the island had not yet experienced a rabbit outbreak.

A few domestic rabbits of the old Belgian hare variety were brought to the island by some of the "farmers" between 1926 and 1928 but their numbers remained static and at a low level. In 1939 the writer saw only two or three rabbits and their few trails were hardly visible in the dense plant growth. Clarence Fry observed a similar condition in 1941. It was thought at the time that the continued presence of house cats was the chief factor in preventing an increase in the rabbits, and while this may have been contributing factor, on the basis of subsequent observations, particularly those of 1938, the writer now believes that the favorable conditions which prevailed in those earlier years allowed the vegetation to grow out of reach and destructive control by the rabbits much as the browse in a deer habitat tends to grow out of reach of the deer and eventually even crowds the animals out. This situation with respect to the rabbits on Santa Barbara Island will be enlarged on more fully elsewhere in this report.

Although the rabbits had no visible effect on the vegetation prior to World War II, the agricultural activities previously described had brought vast and fundamental changes in plant distribution and composition prior to the onset of protection by the National Park Service in 1938. The broad outlines of these changes have been recorded by Dunkle, whose monographic study of the plant ecology of the island brings the story up to the spring of 1942, some ten years prior to the great rabbit outbreak.

Dunkle's studies, supplemented by observations of the present writer on occasional visits, show that sheep grazing and the cultivation of barley or oat hay pushed the *Coreopsis* jungle back to the steeper bluffs and ravines along the eastern edge of the island. Many of the more succulent and palatable wildflowers (*emophila*, *Eriophyllum*) were nearly eradicated. On the other hand, two native cactus species, being inedible and hence released from competition by other diminishing natives, actually prospered and spread so widely and with such density as to make walking in many areas painful and difficult.

For the most part, however, the island became dominated by non-native weed species which had successfully adapted themselves to many centuries of farming and ever-grazing in the Mediterranean Old World. Their seeds probably were brought in on the sheeps' wool and as contaminants in the oat or barley seed that was broadcast for cultivation. Most conspicuous of the invaders were two species of iceplants (), at least one of which became "abundant" as early as 1917 (Howell, p.11).

Dunkle (p.278) noted as early as 1926 that the principal species of ice plant (M. crystallinum) formed permanent dense colonies which so monopolized the ground surface that few other plants could become established. However the ice plant never was able to really take over the island until a considerably later period, after the rabbits had exterminated its competitors.

Prior to National Park Service protection the level part of the island, when not carrying a hay crop, took on the aspect of a vacant city lot being covered with wild oats shoulder high and with dense stands of other non-native grasses such as foxtail and three species of brome, together with associated thistles and mallows of Mediterranean origin.

The natives, when not too heavily overgrazed, clung tenaciously to the ravines and steeper unfarmed slopes. Although not exactly prospering, they held their own fairly well during this period in areas where not directly molested.

Unfortunately relatively few observation on changes in bird life were made at this time but in general it can be concluded that such changes, though drastic were, like those in the plant world, not yet catastrophic. Inhabitants of the Coreopsis "jungle" such as the song sparrow and many flycatchers and warblers obviously were unnaturally restricted. Conversely, birds which require considerable open ground for successful nesting and foraging were favored by the agricultural period. Thus Island horned larks, meadow larks, and burrowing owls, which in prehistoric times must have been scarce or sometimes absent on Santa Barbara Island, came to dominate the open, cultivated areas.

B. After NPS Protection

Again A Temporary Recovery. In the first twelve years under NPS protection from grazing, commencing in 1938*, the native island plants made the most spectacular, ecologically fascinating comeback observed under complete protection anywhere by the writer. This was the golden era of recovery, the only large scale one, so far, since the coming of the white man to the island. It was the more remarkable and scientifically interesting because, usually, native island plants and animals display less vigor than the traditionally aggressive exotics and seldom are able to "push the invaders into the sea."

*

* The Lighthouse Service apparently had the sheep removed about 1937.

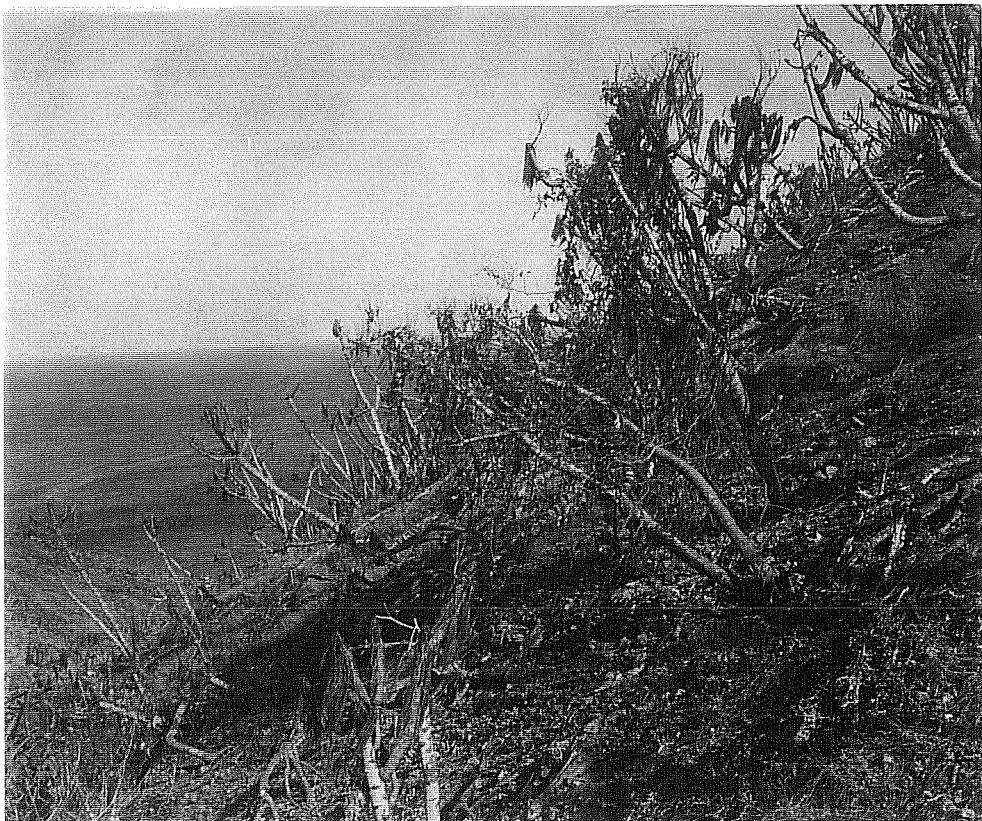
BEFORE AND AFTER

1950

Fig.3. In 1950, the seven foot jungle of tree sunflowers were festooned with Island Morning Glories, and the rabbits had not yet learned how to multiply.

1954

Fig. 4. This is approximately the same spot in Cave Canyon as in Fig.3 above, but in 1954.



Cats and Rabbits Down, Coreopsis Up. In 1939, though evidence of past overgrazing was still prominent the Tree Sunflowers were waist high. This species and other natives already had entered the first phase of their struggle to recapture the island. Erosion gullies were healing, the Santa Barbara Song Sparrow and San Clemente Linnet were abundant in the Coeropsis "forest"; cats were comparatively common and rabbits scarce. This was also a period of comparatively abundant rainfall, which additionally favored the natives. Reconnaissance that year by the Los Angeles Museum Biological Survey disclosed the presence on the sea ledges of 22 sea elephants and a sea otter off shore. Both species had been considered extinct in U.S. waters for about 60 years.

In 1940 two cats were seen during a short visit by a NPS expedition, and only one rabbit. In 1941 Park Ranger Clarence Fry and his wife were assigned to the island for a month in April-May, this being by far the longest field assignment to the area by NPS personnel before or since. Fry killed ten house cats and found that their principal food was the abundant Island mouse. Three other cats were found dead from "natural causes". Relatively few cats were believed to have survived this campaign. Evidence indicated that the reproductive potential of the cats was quite low and that a shortage of water in mid-summer probably was a major cause of "natural" mortality, particularly among the young animals. The Frys saw only two rabbits during their stay, these being adults of the Belgian hare strain.

Men Again in World War II. World War II terminated scientific observations for ten years and set the stage for another violent swing of the ecological pendulum.

The Navy established an observation post on the island. Heavy cargo-unloading facilities, a lookout tower, telephone lines, a road, water tank, barracks and other buildings were constructed and used for some time, evidently by a sizable contingent of men.

More Rabbits. During this military occupation period certain individuals evidently brought over additional rabbits, this time of the New Zealand Red strain. Box traps still present on the island indicate that the rabbits were turned loose to forage off the land under a plan of recapturing them for food as needed.*

*

* Some sheep also were liberated but Don DeSpain reports that fishermen apparently shot these for food after the Navy left.

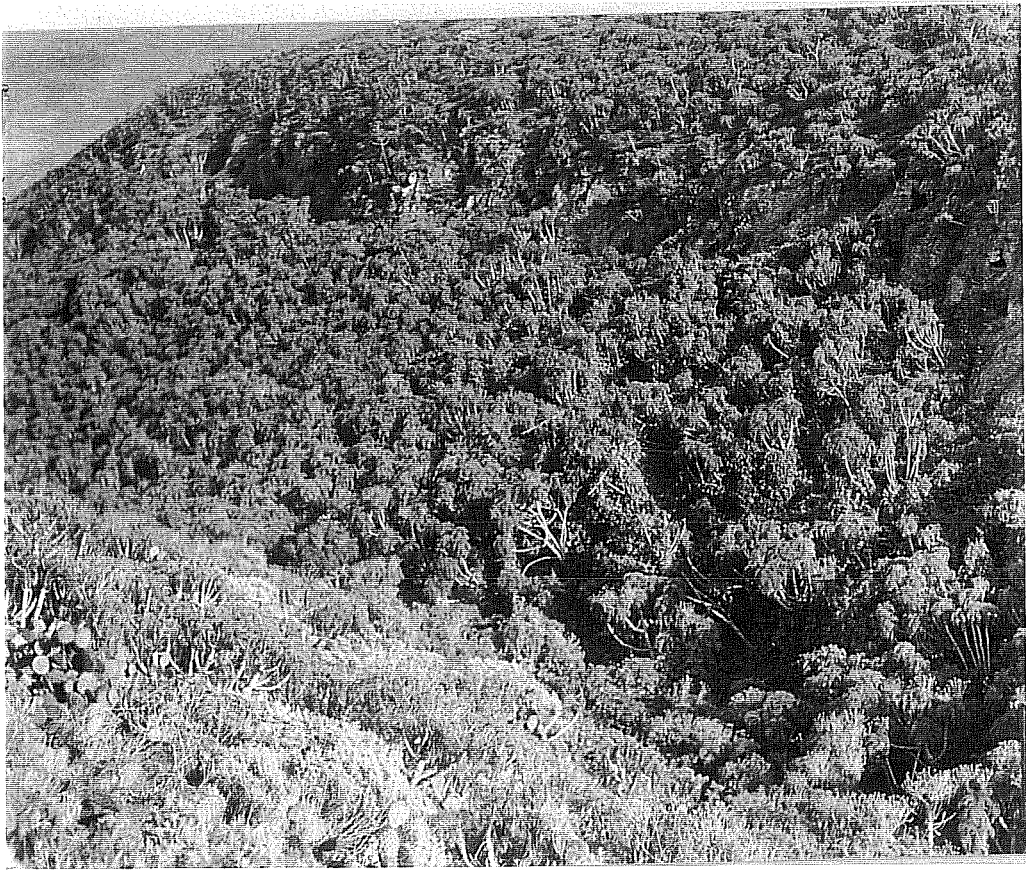
BEFORE AND AFTER

1950

Fig. 5. Tree sunflower jungle in Cave Canyon before the rabbits.

1953

Fig. 6. Cave Canyon crisscrossed by rabbit trails in 1953.



Continued Plant Recovery for a While. In 1950 when biological observations were again resumed by the National Park Service the ecological effects of this new rabbit introduction were as yet scarcely evident. Two sub-adult rabbits were seen but the native "jungle" had reached such a peak of recovery that rabbit trails were almost invisible. One house cat was found dead from "natural causes", so it was obvious that they had not been exterminated decimating from other adverse factors. The Island Mouse, Song Sparrow and Linnet were abundant.

Science lost a great deal when the 1940-1 studies of plant ecology by Dunkle were not resumed in 1950, the year of maximum recovery. Up to that year the return of the natives constituted a most impressive conservation story as well as a scientific demonstration of the ability of an island climax vegetation to win a position approaching dominance from a heavy invading force of exotics, at least under certain conditions.

Coreopsis Still Up. Large areas of Coreopsis which had been waist high in 1939 were head high in 1950. A younger generation was recapturing the old hayfield, growing up through interstices in the abandoned farming implements and covering them from view.

Cactus and Burrowing Owls Still Down. Extensive cactus patches which made walking difficult in 1939 had been overwhelmed in 1950 by the spreading of Coreopsis, morning glory, soap plant, and box thorn (Lycium californicum). Deprived of sun the cactus rotted and collapsed in the damp air of the "jungle", and survived with old time vigor only on a relatively few dry, south-facing slopes. The wild oats and Mediterranean weeds of farming days were in many areas reduced to isolated, progressively shrinking colonies under the engulfing pressure of the natives.

No live burrowing owls were seen in this wilderness of tall vegetation, which would have largely prevented them from hunting for mice. In fact the mummified remains of a single bird, found in a cave constituted the only record then known to the writer of the recent presence of this species on Santa Barbara Island.

Meadow larks and Island Horned Larks, which cannot tolerate tall grass, were few in number and confined to restricted short grass areas near the crestline of the island.

Rabbit Flare-up, Coreopsis Down. Another visit to Santa Barbara Island was not possible until 1953, by which time it was instantly apparent that the island was in deep trouble. Rabbits, all of the New Zealand Red

strain, ran about in great numbers. The Coeropsis "jungle" had a stricken report. Many of the trees had been girdled and felled by the rabbits in their efforts to obtain moisture from the thick, succulent trunks. Throughout the thinning stands of survivors, bare ground showed everywhere through a shriveled carpet of dying vegetation for the first time in the island's history as experienced by the writer. This was because nearly all the "forest" understory of low annuals, and of perennials such as the trailing morning glory, had been killed by the rabbits.

Burrowing Owls Starting Up. So sparse was the ground cover that few places of concealment were available for the Island Mouse. They ran about continually in the daylight, which is not normal mouse behavior, and darted just ahead of the observer like sparrows from the dead sticks and litter under foot.

The former hayfield, once shoulder-high with wild oats, was now in ankle-high stubble as though run over by a mowing machine.

Live burrowing owls were observed this year for the first time. They were still in small numbers, but conditions were more ideal for mouse-hunting activities and the owls were nesting. No cats were seen, but a few of their droppings were noted along the old road leading to the marine navigation beacons.

It was obvious that fifteen years of ecological recovery were about to be nullified and that drastic rabbit control operations would be absolutely imperative to rescue the native vegetation from extinction. Accordingly the technical assistance of the Fish and Wildlife Service and the logistic support of the California Department of Fish and Game were obtained for a major control program, scheduled for 1954.

3. The Rabbit Control Programs 1954 - Spring of 1958

1954 Program. In October 1954 the first official control party, consisting of National Park Service and Fish and Wildlife Service personnel, arrived on the island. We learned that numerous unofficial and unauthorized rabbit hunts already had been held by parties of fishermen and other visitors as rumors of spectacular rabbit shooting opportunities on Santa Barbara Island spread to the mainland. These unauthorized hunts were estimated to have resulted in the destruction of about 100 rabbits.

The 1954 control party found that vegetation had now been almost unrecognizably reduced from the luxuriant condition of 1950. Destruction now equaled or exceeded in intensity anything that must have prevailed during the early sheep and goat eras. Moreover it extended to nearly vertical cliff areas inaccessible to sheep or man, thereby threatening the existence of individual plants that in earlier times might have been counted on to escape and eventually repopulate adjacent devastated areas.

Coreopsis, Morning glory, etc., Disappearing, Cactus Up Again. Living vegetation was so sparse that rabbit shooters could walk almost anywhere through the withering jungle. The rabbit population now so far exceeded the available burrows and concealing thickets that scores of the animals crouched in plain sight on the bare ground, taking advantage of any slight shade afforded by the surviving Coreopsis. Acres of box thorn, island sagebrush (Artemisia californica insularis) had been exterminated. The giant morning glory was reduced to a few leafless, prostrate runners except where an occasional plant had been able to put out a few leaves beyond reach of the rabbits by climbing to the top of a still-standing Coreopsis.

By contrast the cactuses had had several years in which to dry out, and now were spreading. Iceplant, apparently unpalatable to the rabbits, was little changed in extent, so far.

Burrowing Owls had now become common, while short-eared owls and Cooper hawks, not previously observed by the writer, were much in evidence, reflecting increased capturability of mice and songbirds.

The Santa Barbara Song Sparrow somehow maintained fairly large numbers in the dwindling forest, but the San Clemente Linnet was noticeably scarce. Island Horned Larks and meadow larks were now on the increase.

Rabbit Control Inconclusive in 1954. In the first season of operations, the full scale use of poison had not yet been authorized by the National Park Service. Chief reliance was placed on control by shooting, but some limited experimental poisoning was tried out in an isolated 15-acre area.

Four men spent six full days in shooting four hundred rabbits, and 150-200 additional animals were estimated to have survived in inaccessible places, or to have been missed in the numerous drives.*

*

* It is now suspected that this estimate of surviving animals was too low.

An additional 12 animals were estimated to have been killed by the experimental use of strychnine-coated rolled oats. Effects of this poison on other species of wildlife were demonstrated to be negligible. Thus the total score stood, roughly, at 400 rabbits shot by the official control party, 100 shot by previous unauthorized shoots, and 12 poisoned, giving a total of 512 animals killed and perhaps 200 still at large on the island at the conclusion of the operation.

Significant features of this first season's results were (a) the relatively large numbers of animals that escaped after 6 days of intensive and repeated drives by experienced shooters (b) the fact that each man hour devoted to poisoning resulted in approximately 5.3 dead rabbits, versus only 2.6 rabbits killed per man hour of shooting effort.

It was also significant, in the light of subsequent developments, that all of the rabbits were in good flesh.

1. Shooting has value as a supplementary control method but cannot be relied on as a means of exterminating the rabbits. If long continued it will hasten the destruction of certain brittle types of native vegetation, particularly *Coeropsis*, box thorn, and Island Sagebrush, through trampling and breakage by the hunters. Its efficiency might be somewhat increased by constructing wings of wire mesh to herd the driven animals into corrals, but construction and maintenance of such wings and corrals would add considerably to the outlay of man hours.

2. A further introduction of cats, or other predators, might control the rabbits eventually, but such predators would, if they could survive without water, be a constant threat to the nesting sea birds.

3. Trapping would be prohibitively inefficient since water is not available as a lure.*

4. Mosquitoes are absent, hence not available for spreading an introduced rabbit disease as in Australia.

5. The use of poison, prepared in such form and distributed in such manner as to have negligible effects on other wildlife, offers the only real hopes of eventual eradication of the rabbit population.

*

* Repeated criss-crossing of the entire island during the shooting drives revealed that, due to increasing aridity in recent years, the small seep reported by Dunkle and Fry is no longer in existence.

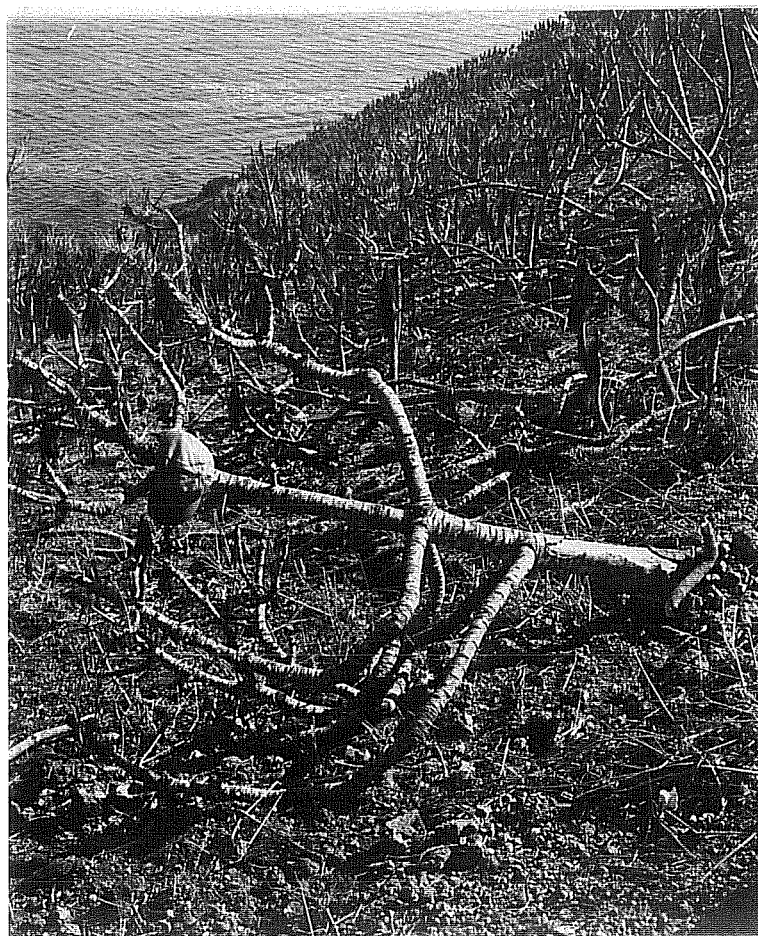
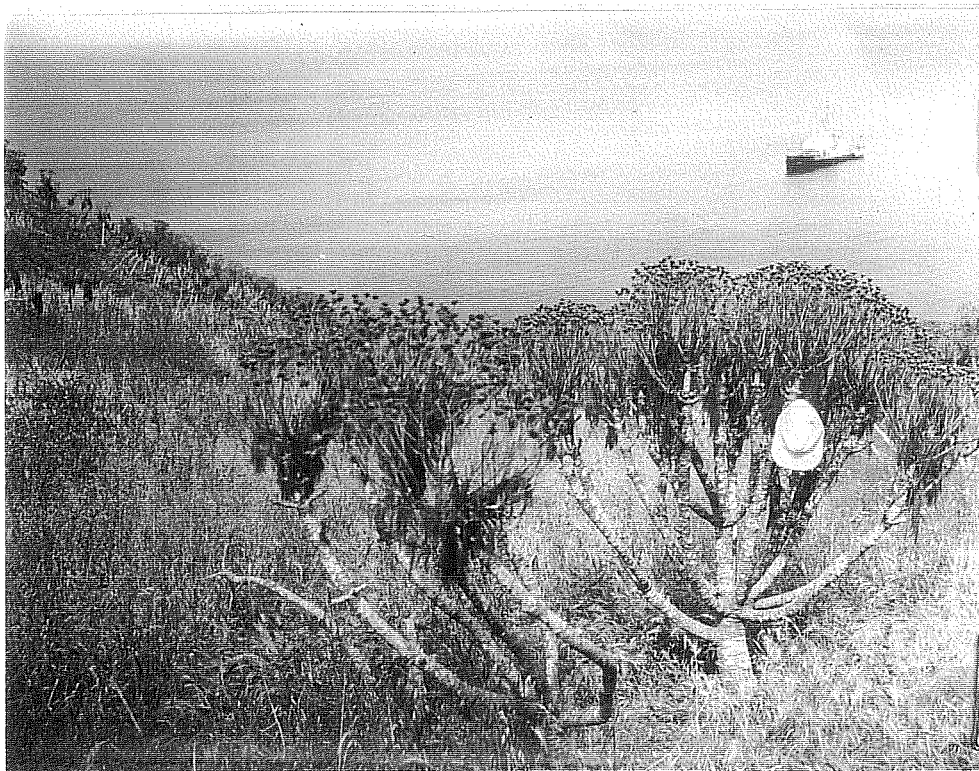
BEFORE AND AFTER

1950

Fig. 7. The "Grizzly Giant," largest sunflower known to the NPS, before the rabbits. Trunk 3 inches in diameter.

1954

Fig. 8. The "Grizzly Giant" in 1954, felled by rabbits.



1955 Program. A reconnaissance visit was made in mid June. This was primarily for fall planning purposes, inasmuch as it was known that rabbits surviving from the previous year would not be interested in rolled oats until after the season of green vegetation, and that many young rabbits born during the spring would not be old enough in June to accept this type of bait.

Coreopsis showed no appreciably increased beavering by the rabbits. Morning glory, a number of rabbit food, showed a temporary and limited revival of new shoots above the root crowns, although most of the original long leader system of previous years was dead.

Iceplant (M. crystallinum) had staged a conspicuous, large-scale invasion of previously denuded ground and extended even beneath the Coreopsis, where it replaced the native wildflowers of earlier years. Thus in the long run the greatest change wrought by the rabbits conceivably might be this widespread process of replacement by iceplant.

Rabbit Reproduction proved through examination of females shot, and analysis of age classes in the surviving population, to have been largely limited to a single generation per year. This is due no doubt to their inability to maintain reproduction after the disappearance of green food with the onset of the dry season, and certainly is a major biological factor working on the side of ultimate control.

Our party of four shot 206 rabbits in the one-day period covered by this reconnaissance. We estimated approximately 90 others shot recently unauthorized persons or total of some 300 shot, with an additional 400 that survived these preliminary shoots and consequently would have to be dealt with during the major control program scheduled for October. These rabbits were in good flesh, as in 1954.

Rabbit Control Was Conclusive during the 3-day period in October when poison was first used on a full scale basis. The five-man party shot 191 rabbits; shot an estimated additional 230 rabbits. The estimated kill by poison was approximately 2,175 rabbits for the fall period, plus the previously indicated total of 300 by all parties for June, or a grand total of about 2,500 animals during 1955. These rabbits, as in previous cases, were still in good flesh.

We estimated that even with this decisive use of poison, perhaps 100 rabbits survived because some lived on sea ledges inaccessible

BEFORE AND AFTER

1950

Fig. 9. In 1950, before the rabbits, waves of advancing native vegetation were smothering the cactus.

.....

1953

Fig. 10. Approximately the same area shown above in Fig. 9, after being moved by the rabbits. Old hay press.



to humans, while others probably did not find the poison bait stations until most or all of the bait had been consumed by other rabbits. Subsequent events in 1956 and 1957 forced us to revise the estimated number of survivors upward to about 150 animals, however.

Cats were not seen except for one adult female which was shot and found to be fat and in excellent condition; however it was definitely a non-breeder. We concluded that the cat population has declined over the years primarily because increasing aridity has made survival increasingly precarious, particularly for kittens. It was been several years at least since free water was available during summer other than free irregularly occurring fog and dew.

Island mice were for some reason not as conspicuous as on previous visits, possibly due to the fact that burrowing and short-eared owl populations had continued to hold steady.

1956 Program. The spring reconnaissance could not be made, but the mid-October control program was carried out on the same scale as for the previous year.

Surviving Rabbits showed a new development--for the first time since control was commenced in 1954, members of the population now were, with occasional exceptions, uniformly bony and in poor flesh. Obviously despite their reduced members the nutritional level had fallen even more rapidly than the population. This situation indicated a comparably bad condition for the vegetation of the island which was soon confirmed.

Surviving Edible Vegetation had reached a new low, evidently because of a combination of continued aridity and the fact that the rabbits, though fewer than ever, were still too many for the reduced carrying capacity and enfeebled reproductive powers of the remnant of edible plants.

Coreopsis had been reduced by 25 to 30 percent through beavering, girdling and undermining. Wild cucumber, formerly common but not a preferred rabbit food, was reduced to an occasional small green runner. Morning glory, the best indicator of rabbit pressure, was so far gone that in three days the writer found only one plant that showed slight signs of current life. Small wild flowers seemed almost non-existent, and even the hardy Mediterranean grasses were greatly reduced.

Cactus showed a general increase, particularly the more spiny and aggressive "jumping cholla" (Opuntia prolifera).

Iceplant continued to spread enormously, forming dense carpets on most of the open ground outside of the Coreopsis patches. By now it had replaced most of the native plants and had even to a large extent replaced the dense wild oat stands in the former hayfield. Since this species seems to be largely unpalatable to the rabbits the poor conditions of the latter may be one of the many consequences of the spread of the iceplant, which in its turn is an ecological consequence of the original outbreak of the rabbit population.

Rabbit Control in 1956 was more drastic than ever as a result of continued poisoning but the benefits were less conclusive than had been hoped for because of the continued decline in the vitality and carrying capacity of the remaining vegetation as previously described.

Rabbit shooting, as well as the physical condition of the animals, had never before been so poor. Our four-man party spent three days (about 12 hours per man per working day has been the general average) shooting 102 rabbits and poisoning an estimated 450. This plus an estimated 50 recently killed by unauthorized persons gives a grand total of 602 rabbits accounted for.

As in 1955, the preliminary field estimate was the possibly 100 rabbits might have survived the poison operation of 1956. However further consideration of the demonstrated reproductive potential of the Santa Barbara Island rabbit population made a revision of this estimate necessary: We had just killed 600 individuals produced from the 1955 population of survivors, and had again allowed 100 (or more) to escape. Continuing examinations of females substantiated the original belief that as a rule each female produced only one litter per year. Consequently, to produce an annual kill of 600 animals on a sustained basis, as these rabbits unfortunately now seemed to be doing, approximately 150 animals obviously would have had to survive the control operation of 1955. And if that many had survived in 1955 it was probable that they had done so again in 1956. In any case, the condition of the vegetation showed that the current number of surviving animals was too high to tolerate.

A House Cat was reported recently shot by an unauthorized person. The Island House, though still common, was not as abundant as it had been before the increase in burrowing and short-eared owls, which remained common. Island Horned Larks and meadow larks also were common.

1957 Program. The Spring Reconnaissance visit showed that we were barely holding our own. Vegetation showed some new spring growth as was to be expected, but the volume was small and vitality obviously was still low. There was no time for a major rabbit hunting effort, but small young rabbits were rather numerous.

By now it had become evident that to achieve a high kill in the fall, a substantial amount of time would have to be spent on mop-up operations after the initial coverage of the island had been completed. The writer expressed a willingness to remain on the island in the fall to conduct such a mop-up for approximately three weeks after the inter-agency work party had completed a week of initial coverage and had returned to the mainland. However due to various logistic and scheduling difficulties it was finally agreed instead that all members of the inter-agency group would remain on the island for a substantially longer period than in previous years in order to cover the area with poison three times in lieu of the once-over treatment that had been given in previous years.

Fall 1957. Rabbits were almost without exception bony and in poor flesh, indicating that they had over-consumed the limited supply of high grade foods and were being forced to subsist on less palatable plant species. The four-man party saw only 25 animals during the same length of time and in the same area where 125 were counted in 1954; and in 4 days of hunting they were only able to shoot a total of sixty six individuals.

Unauthorized hunting by outsiders had tapered off to almost nil, in sharp contrast to conditions in 1954 when it was considered that Santa Barbara Island afforded probably the most dependable and abundant rabbit hunting in the State of California.

The vegetation, however, had suffered a decline even more pronounced than that of the rabbits. Approximately 50 percent of the *Coreopsis* was dead and prostrate. The bulk of the morning glories had been able to keep no leaves or runners, and appeared nearly dead; however twenty or more with limited growth more found below the east bluffs near the sea where rabbit control the previous year had been especially effective.

Even the brome grasses and wild oats were sparse; cheat grass was now the dominant surviving grass but had attained an average height of only 6 inches. The old hay press which for years had been completely covered by the jungle now was a prominent landmark on the short stubble.

The situation was aggravated by the exceptionally scanty rainfall of the preceding winter. Don DeSpain stated that in many years of continuous observation he had never seen any of the Channel Islands as dry as this year.

Iceplant had continued to make enormous gains, occupying nearly all ground laid bare by the rabbits. More than half the surface of the islands now appeared covered by it and it appeared that at the current rate of spread it might comprise 85-90 percent of the vegetative cover within the next 5-10 years.

Although occasional patches, 10-14 feet in diameter, were found that had been denuded by the hard pressed rabbits, the low palatability and nutritive value of this plant evidently was a significant factor in the poor condition and continued decline of the rabbit population. In addition to replacing the native high grade food plants the iceplant had become an increasingly severe physical obstacle to the animals. Extensive areas of formerly open ground now were so covered with its dense, wet and slippery leafage as to discourage travel by both men and rabbits.

Rabbit Control reached a new level of thoroughness on this visit. Because the dense carpets of iceplant now denied more than half of the surface of the island to the rabbits, our four man crew was able to cover the infested areas four times in seven days.

A new procedure was added to the program this time. This was an initial coverage of all infested areas with unpoisoned rolled oats to stimulate full acceptance of the bait. The latter was consumed in all inhabited areas very completely.

The second coverage was with the standard strychnine-coated rolled oats, and this likewise was eagerly accepted.

The third coverage was with alfalfa hay that had been dipped in a strychnine solution. Unfortunately the hay did not dry well after dipping, due to the prevailing humidity, and had a tendency to ferment. And there was only enough of this material to cover the most heavily infested areas. Little or no acceptance of the hay was observed. In part this was due to the high effectiveness of the preceding oats application, which left few survivors. But lack of attractiveness also seemed to be a factor.

The fourth coverage was again with strychnine coated oats. Very few rabbits were noted still running about prior to this last application and only two or three afterward.

At the conclusion of the operation it was estimated that a total of 500 rabbits had been killed by poison and shooting. Only two live animals were seen at the end of the seventh days. We concluded that to produce a kill of 500 animals, plus a few inevitable survivors, the population that we must have left on the island at the close of the previous year's operation (1956) must have numbered about 125 animals, a slight improvement over the 1955 rate of survival.

We estimated that the number of animals surviving the operation just completed to be in the neighborhood of fifty or less.

Two gulls (out of approximately 2,500) were found apparently poisoned, the only poisoning fatalities other than to rabbits and mice so far observed.

Cats were not seen but apparently one or two still survived, as indicated by a few droppings along the old road. Mice were not as much in evidence as in the earlier years but the iceplant would in any event have made them harder to see. The fact that burrowing owls remained as common as ever indicated that the mice might be about at recent levels (though burrowing owls are also heavy insect-eaters).

Santa Barbara Song Sparrows were fairly numerous but by no means abundant; San Clemente Linnets uncommon.

Horned Larks remained common but the ever spreading iceplant was threatening to obliterate most of the open ground that they require for nesting.

1958 Program. The Spring Reconnaissance showed a new and heartening ecological development. The preceding winter had been one of the wettest on record in Southern California (none comparable since 1937), and had helped the surviving vegetation in its battle with the rabbits to greater effect than anything we had been able to accomplish thus far by direct control.

Surviving Coreopsis were putting on a blazing show of golden yellow. Being slow-growing shrubs, they could not be expected to recover soon from their 50 percent decimation, but the first new young plants of this species since the rabbit outbreak were now observed. The number of such young plants was considerably less than 1/2 of 1 percent of the total stand, and some of them had been partly eaten by rabbits, but the mere fact of their survival was encouraging.

Morning Glory had revived appreciably, even in areas where most of the plants had during the previous two years appeared virtually lifeless. For the first time in several years their showy white trumpets again decorated the wall of the ravines. Box thorn showed the first extensive development of new leaves in years, though approximately 35 percent of the original stand was dead. Island sagebrush exhibited strong recovery. Wild cucumber had revived.

Wild oats showed another abrupt change of status in the ecological struggle: Long dominant in the old farming days, it was nearly smothered out by natives in 1950. Released from this competition by the rabbits it had briefly regained dominant status only to be severely cut down again as the rabbit population multiplied. Partially freed from rabbit pressure by our control operations it was now--more than 20 years after the original plantings--able to take advantage of the rains this year to grow waist and shoulder high once more in such dense stands that the rabbits no longer could penetrate it. The foxtail and brome grasses experienced a comparable resurgence.

Cactus, particularly the prickly pear species (Opuntia littoralis), was once again on the down grade in many areas, being overrun and smothered by various semi-prostrate and climbing annuals such as bedstraw.

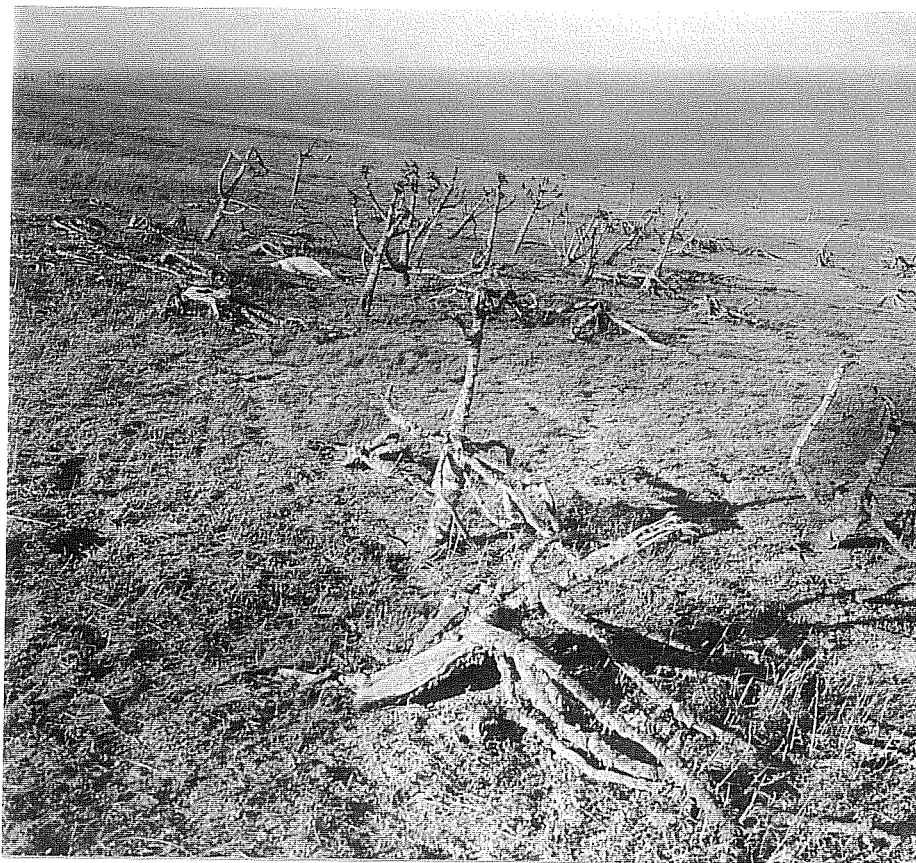
Iceplant had attained astounding luxuriance and density, forming on 50 percent or more of the island a tough, slippery, wet barrier twelve to eighteen inches deep (!) very difficult for human beings to wade through and impenetrable to the rabbits.

The short range implications of this iceplant dominance were favorable for rabbit control, but the long range outlook for its replacement by native appeared ominous.

Rabbits were, temporarily at least, being dominated by the reinvigorated vegetation, for the first time since 1951 or 1952. Like ground squirrels and prairie dogs, which cannot tolerate a tall grass habitat and must move out if they cannot maintain adequate clearings in it, the rabbits had become concentrated into various semi-isolated communities in three major but widely separated parts of the island.

Fig. 11. Here more than 50 percent of the largest *Coreopsis* stand remaining in the world has been felled by the rabbits.

Fig. 12. These succulent shrubs of the Pleistocene Age were not fitted by nature to withstand grazing animals, or beavering by rabbits.



The rabbit communities were interconnected by runways through the tall grass the way human communities are connected by highways through forest country. The more flourishing rabbit communities also were marked by areas cleared for living purposes, like forest clearings in areas of human settlement. But rabbits traveling between communities were largely restricted to the highways.

Thus it can be conjectured that the rains had been as effective ecologically in limiting the rabbits as poison, or more so, but also that if control measures had not been used previously, the unchecked rabbits would have remained dominant, in which case the vegetation would have been too reduced and enfeebled to stage a comeback when favored by the rains. Significantly, all rabbits collected were again in good physical condition, reflecting the restoration of adequate food supplies after two years of inadequate nutrition.

Cats and Mice could not be adequately investigated during the short time available for reconnaissance. Conceivably if the old time seep, previously mentioned, should revive, the cats might have an improved chance for survival, but there was no evidence that the seep had done this. However, temporary water was present in the two remaining old time sheep cisterns, for the first observed time since 1939.

Fluctuations in status of the Island Mouse since 1954 may have been more apparent than real, expressing primarily the difference in vegetative cover that would make it easier or more difficult to see these animals. In 1958 the density of the cover made it very difficult to see them. However our overall impression has been that at no time unless possibly during 1955 has this species been seriously threatened.

Burrowing owls*, horned larks and meadow larks, however, faced an unpromising future due to the rising tide of vegetation particularly the iceplant. Only one burrowing owl was seen. Horned larks were still nesting along the ridge crest of the island, where the iceplant always has been lower in density and height, but even here their nesting territory was gradually becoming untenable. Meadow larks, which prefer much taller nesting cover than horned larks, were still about the same as to numbers.

Song sparrows were still holding their own and were expected to have good nesting success in their reviving jungle habitat. San Clemente Linnets were not seen however.

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* The short-eared owl is a fall migrant to the island, consequently its status in 1958 could not be determined during our spring visit.

6. The 1958 Rabbit Population and Outlook

A New Low. At the end of the intensive 1957 fall control program we had hopefully estimated the number of surviving rabbits at fifty or less. Following the 1958 spring reconnaissance Warren Bloys roughly estimated a possible 75 rabbits currently on the island and Sumner guessed 50. Grom guessed 160 because at the time of the estimate we had actually seen 16 animals and it is often considered that with a concealment-seeking animal like a rabbit one sees only about one-tenth of the total population. However, by the end of the one day reconnaissance (actually two half-days) our three-man shooting party had killed 17 animals and had seen about 10 others, or 27 in all.

All three guesses included young animals produced by last fall's survivors, so in any case these survivors appeared to have numbered not much over 60 animals at the conclusion of the 1957 control program. Moreover it seems quite possible that during the 1957-58 winter season, which began with early rains, some of the adult females might have been able to produce two litters instead of the customary one.* Such a situation was further suggested by the good condition of all rabbits collected. And by the fact that some 1/2 to 3/5 grown young animals were running about (though not themselves breeding) to show that the breeding season had, in some cases at least, commenced early in the year--while at the same time all adult females shot by us contained 6 or 7 (usually 7) embryos. Thus some of these females conceivably might have been bearing their second litter of the season.

The Outlook - Climatic Assistance Not to be Relied On. Dominance of the vegetation over the rabbits is a potent, though possibly only a temporary ecological condition. The future alone can tell whether wet winters will continue to occur with sufficient frequency to let the vegetation keep its lead. We have reason to believe that such was the case up to 1939 because rabbits had existed on the island for many years prior to that time without having been able to destroy the vegetation and without artificial control.

On the other hand it is clear that during dry cycles the rabbits may win out, at least if they receive an extra boost in the form of an additional introduction from the mainland as occurred during World War II. Under such conditions only drastic, unrelenting annual control seems to offer any hope of saving the vegetation. We have not yet proved that control alone, without the assistance of a wet year, can wholly eliminate the rabbits, but it seems clear that we must make every possible effort to

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* This some possibility, though reduced, may have complicated our population survival guesses to some extent is the preceding less favorable years too.

perfect a completely effective extermination technique because of the impossibility of relying on weather to help us. This means that every effort should be made during the fall of 1958 to follow up the first real, but so far inconclusive and temporary victory that a favorable season has given us. Absolute extermination now, when conditions for its achievement are most promising, must be the goal.

Iceplant, A Grave Question Mark for the Future. Even if the battle against the rabbits is finally and conclusively won we cannot yet be sure that the larger task of restoring nearly original ecological conditions to Santa Barbara Island can be accomplished in the face of the rampant more intelligently on the basis of additional ecological research-which it is hoped can be pursued more continuously and effectively than in the past.

In the meantime complete removal of the rabbits will be an absolutely essential first step toward restoration.

7. Recommendations

A. Make a Supreme Effort, with the technical advice and assistance of the Fish and Wildlife Service, for Total Extermination of the rabbits in the fall of 1958, when ecological conditions should be more favorable for success than at any time in the past.

B. Step Up Basic Research to a point where it can (a) adequately observe and record the most significant ecological changes occurring on the island, (b) make a reasonable forecast as to the chances of recovery of the native biota with respect to invasions of both rabbits and iceplant, and (c) relate the entire ecological history of the island to the interpretive program.

C. In consultations with the Fish and Wildlife Service, and others were appropriate, plan for approximately three weeks of field work about September 1958 on the part of a team of biologists, and scientists in _____ Ecological fields, for attaining these combined objections.

Rabbit War Over On Santa Barbara Island

LOS ANGELES (AP)—Santa Barbara Island's Rabbit War is over; the Ice Plant War is just beginning.

Man's victory over the rabbits — accomplished in 1958 after a four-year extermination battle — spared the island's numerous varieties of rare plants from the animals' hunger.

Finally, using poison as well as bullets, the people finished off most of them.

Mother Nature cooperated in the rabbit hunt by providing the ice plant. Now if she'll only produce a bit more rain, Santa Barbara Island will once more become a scenic beauty spot.

BUT NOW MOTHER Nature must be overcome if the national monument some 40 miles off the coast southwest of here is to regain its lush vegetation, all but destroyed by gnawing rabbits.

As the furry creatures ate up the rare plants, nature replaced them with ice plant, which now covers about 85 percent of the land, in dense growths 12 to 18 inches deep. Rabbits won't eat ice plant.

The only practical weapon available to overcome the creeping ice plant is moisture. If wet weather persists, the remaining rare plants may well spread back to sections of the island where they haven't appeared since the rabbits began chewing their way to extinction.

That was before 1950, when the island was covered with giant sunflowers and species of song sparrows and other plants, birds and small animals found nowhere else in the world.

IN THAT YEAR the rabbit population suddenly increased due to good weather conditions. They left the once lush growth so barren in many spots that it looked as if a devastating forest fire had ravaged it.

In 1954, state and federal officials went to war against the rabbits. They shot as many as possible, but many others stayed hidden in steep, inaccessible terrain bordering the ocean.

The officials returned every year and killed more rabbits. But the animals kept multiplying, as rabbits will.

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