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Crop damage by wildlife in California ; with special emphasis on deer and waterfowl

Earl Roy Biehn
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CROP DAMAGE BY WILDLIFE IN CALIFORNIA WITH SPECIAL
" EMPHASIS ON DEER AND WATERFOWL

A Thesis
Presented to
the Faculty of the Department of Zoology
College of the Pacific

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts

by
Earl Roy Biehn
June 1950

Author

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Thesis

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Wildlife Service, who are not previously mentioned, for assistance and information; and to many farmers and sportsmen who have given information and cooperation during this study.

Special appreciation is expressed to my wife, Mary Adele Biehn, for constant assistance and untiring interest.

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METHODS OF INVESTIGATION

The information contained in this thesis was obtained from the following sources: (a) From published and unpublished reports in which crop damage by wildlife was mentioned or from material that dealt with the management of deer and waterfowl; (b) from the files of the Imperial County Game Depredations Committee; (c) from the deer damage records and file of Dr. Tracy I. Storer, Professor of Zoology for the University of California at Davis; (d) from the files of the Department of Natural Resources of the California State Chamber of Commerce; (e) from the files of the Agricultural Committee of the San Francisco Chamber of Commerce; (f) from deer damage shooting license tag returns furnished by the Bureau of Patrol of the California Division of Fish and Game; (g) through the medium of questionnaires sent to Agricultural Commissioners, Farm Advisors and Game Wardens throughout the state; (h) from attendance at the Pacific Flyway Biologist meeting and the Fifteenth Annual North American Wildlife Conference held in San Francisco in March, 1950; (i) from personal interviews with officials of the State Department of Agriculture, Farm Advisor's office, California Division of Fish and Game, Nevada Fish and Game Department, U. S. Fish and Wildlife Service, with the chairman of the Game Depredations Committee, farmers, and with sportsmen by discussing this problem at sportsmen's club meetings; (j) from personal observations of the writer which

included an experiment to determine the amount of damage to a pastureland in San Joaquin County by waterfowl, and by frequent trips to many areas of northern and central California including the winter range of the Interstate Deer Herd in Modoc County, the Capay Valley in Yolo County, the Tule Lake National Wildlife Refuge in Siskiyou County, the Grey Lodge State Waterfowl Refuge, the "Butte Sink" and the "Colusa-trough" in Colusa and Butte Counties and other areas where crop damage by wildlife was in evidence. More than 3500 miles were traveled by the writer in securing the data for this study. The data so gathered, the conclusions based thereon and the authorities cited are contained in this thesis.

INTRODUCTION

The problem of crop damage by wildlife is not a new one in California, but it has assumed a role of major economic importance only during the last few decades. Since this problem was first encountered in California, it has steadily increased in size and scope, until today in many areas of the state it is an important economic problem of the farmer; a pressing management problem for the biologists and wildlife technicians of the California Division of Fish and Game; a constant challenge to the game management agents of the Federal Fish and Wildlife Service; a great concern of the State Department of Agriculture and the State Chamber of Commerce; and of great interest to many California sportsmen and conservationists.

Although there are many who feel that competition between wildlife and agriculture is comparatively new, the records show it to be of ancient origin, and of world-wide distribution. When man learned to till the soil and to keep domestic flocks so that he might be assured of a more stable supply of food, the wild creatures that were accustomed to feed upon these animals and plants soon learned that man's activity made available for them also an adequate food supply. This then could be termed crop depredation in all its simplicity.

In California, crop damage by wildlife probably started with the initial farming practices of the early

Spanish missionaries and settlers who later taught the native Indians how to grow cultivated crops as a supplement to their natural diet of wild plants and animals. When the Spanish first settled in California they brought with them exotic seeds from their own country as well as of others. As the population increased more land was utilized. At this time the damage by wildlife was probably limited to a few birds, small mammals such as rabbits, squirrels and other rodents. The earliest records of any depredation in California were written by the Spanish Padres who founded the early California missions and had planted a few flowers, fruit trees and vegetables. These padres noted that small mammals and birds were also living off these plants, but were not doing serious damage.

In 1848 gold was discovered in California. The following years brought thousands of gold-hungry men and women into this land. Some found their fortune but many more did not. A large part of these new settlers became a nucleus for the large population of farmers that soon sprang up in California. More land was soon dedicated to the growing of food crops as water was drained from the wet lands and brought to the arid lands; forests were replaced with vineyards and orchards in many parts of the state. The results of these practices are obvious. The natural habitat for wildlife was decreased as was the available supply of natural feed.

Many of our native creatures could not adjust themselves to the inroads made by civilized man. Some retreated farther back into the hills and primitive areas, while others declined in numbers or disappeared from the scene entirely. But on the other hand we find certain species that found the food and shelter afforded by man to their advantage; concentrated fields of highly bred native plants and exotics from other countries have produced for them food supplies more abundant and more attractive than were the hardy native species of plants. These species have lived and thrived, and it seems probable that many of them are more abundant today than they were in years long past. (Neff, 1949)

As the numbers of acres under cultivation increased, so did the competition between man and wildlife increase. In some areas of the state these increases were almost in direct proportion to each other.

Crop damage in California is accomplished by various species of mammals and birds. Most of the damage, however, may be summed up as follows:

1. Annual destruction of lettuce in the Salinas-Watsonville area by large numbers of horned larks, Otocoris alpestris actia Oberholster.
2. The debudding of apricot and almond trees by linnets, Carpodacus mexicanus frontalis (Say).
3. Annual damage to cereal crops in the San Joaquin and Sacramento Valley by blackbirds, Agelaius phoeniceus californicus Nelson, Agelaius tricolor (Audubon) and Euphagus cyanocephalus (Wagler).
4. Annual damage to rice, grain, truck and pasture crops in the Tule Lake area; and in the Sacramento, San Joaquin, and Imperial Valleys by

- resident and migratory waterfowl.
5. Damage by rodents to field and pasture crops and to young orchards and vineyards throughout the state.
 6. Melon damage by coyotes, Canis latrans estor Merriam in the Imperial Valley.
 7. Annual damage by wild pigeons, Columba fasciata monilis Vigors, to orchard and truck crops.
 8. Damage by rabbits, Lepus and Sylvilagus to fields and pasture crops and to young seedling trees and vines.
 9. Damage by deer, Odocoileus hemionus columbianus (Richardson) and Odocoileus hemionus hemionus (Rafinesque) to field and pasture crops, orchards and vineyards.

Of these nine general wildlife groups, deer and waterfowl do a large part of the annual damage in the state today. Crop damage by these wildlife species present an ever-increasing challenge to the ability of State and Federal agencies to coordinate their management plans for a three-fold purpose: First, the complaints of the agriculturalist must be met; secondly, the demands of the hunter and the conservationist must be satisfied; and third, the population of these game species must be maintained at a safe level even after meeting the demands of the first two groups mentioned.

CROP DAMAGE BY DEER IN CALIFORNIA

It is difficult to say exactly when crop depredation by deer began in California, but it may be assumed to have started when man first planted his crops within natural deer habitats. It is a well established fact, however, that since its early beginning, the problem of deer damage has been on a continuous and rapid increase.

By 1920 the deer damage problem had become a serious economic threat to California's rapidly expanding agricultural industry. Early surveys of deer damage were made by the U. S. Forest Service and the California Farm Bureau Federation. In 1930 the California State Chamber of Commerce set up a Game Depredations Study Committee to determine the extent of crop damage at that time. (True, 1932) A sub-committee on the survey of deer damage in California was headed by Dr. Tracy Storer who was assisted by Gordon True, Jr. and Stanley Piper. The findings of these men have been used as a starting point for the writer's own study, concentrating on the deer damage problem from 1932 until the present time. Part of the information obtained from deer damage reports was compiled by Dr. Storer who has long been an authority on this problem in California. Dr. Storer has kindly turned this data over to the writer for analysis and partial inclusion in this paper.

This problem is not a simple one and therefore not

easily solved. It may be considered unique in the respect that it involves a greater variety of interests and covers a greater land area than any other form of wild game damage in California with waterfowl damage a close second.

With a great number of people representing many interests being involved in the problem of deer damage, the evaluation of damage and control measures has become highly controversial. It is the purpose of this paper to present the basic conditions underlying damage by deer to show the general picture of damage in the state; and to relate it to what has happened in the past, with possible recommendations for more permanent relief of this problem in the future.

THE NATURE OF DAMAGE BY DEER

There are many types of damage by deer in California. The type of damage depends upon the type of crop damaged. For the sake of clarity the writer has divided this section into specific crop types.

Orchard: The greatest amount of damage to fruit trees occurs during the first one to three years after planting, since, during this time the deer are able to reach the tender terminal shoots. If the young trees can be given protection until the main branches are out of reach of the deer, damage to orchards would be reduced considerably, and damage to older trees is practically negligible in comparison. If these shoots of the young trees are destroyed the first time, the tree suffers a serious setback, but the leaders may grow out again later in the season. If they are again destroyed, death of the tree is a common result. (True, 1932, p. 143) Even if the tree survives, there are many things to consider in estimating the amount of damage. In 1948 the Pomological Society of the State of Maine presented a fairly complete method to use in evaluating deer damage to orchards. For example, each side branch that is injured, up to a limit of five suitable for major scaffold limb development is scored as 10 percent damage. A damaged leader may be scored up to 50 percent loss for trees over one year. One-year whips may be scored 100 percent loss. When it is

necessary to replace a tree, production is delayed for the number of years of age of that tree. For example, a two-year tree in the orchard that is totally lost means two productive years lost to the grower. Trees of bearing age, and which are in production, are given special consideration based on the following points:

1. Extent of area damaged.
2. Actual loss of crop
3. Loss of leaf surface and fruit spurs that may affect the future crop.

The total damage then would be as follows: (Rockwood, 1948,

p. 26)

1.	Tree cost.....	A
2.	Planting cost.....	B
3.	Operational cost...	C
4.	Production loss....	<u>D</u>
	Total Loss=	A+B+C+D

Many farmers reported losses of fruit eaten by deer. In Tuolumne county, orchard men report that deer eat the peaches and spit out the pits. In some cases the ground may be found literally covered with the pits of peaches after a night raid by deer. In many areas of California such as the Napa Valley, Santa Clara, Sonoma and Santa Cruz counties where prunes are grown in large quantities, farmers report that although the deer do not eat many of the prunes off the tree, they eat the windfalls which are just as valuable. Other types of damage occurring to orchards include the girdling of trees by male deer, while polishing their antlers. This type of damage is not great, however. Deer damage citrus orchards by killing small trees, eating



Figure 1. Almond trees damaged by deer in Capay Valley, Yolo County. Note complete defoliation of lower branches. Photo by H. A. Hjersman, August 10, 1949. (Courtesy of California Division of Fish and Game)

the foliage of trees of all ages, and by breaking branches with their antlers. The fruit of citrus, avocados, and olive trees are not considered as very palatable to the deer, while the fruit of the apricot, cherry, peach, pear, apple and prune trees are eaten in many cases where deer can reach them, or if they have fallen on the ground. The nuts of almonds are eaten some, while walnuts are rarely taken.

Truck Crops: Damage to truck crops include many varieties of plants, see fig. , as does damage to orchard crops. Most truck crops are damaged by the deer eating the plant themselves, from the time when the plants first make their appearance until the crop matures. Deer prefer eating the young plants rather than the mature fruit or vegetables. In many cases the damage occurs from the deer trampling the plants by walking or wallowing on them as well as eating them. In the case of strawberry fields, the damage is caused by the deer walking in between the rows and thereby breaking the innumerable runners sent out by the "mother" plants. This reduces the yield of young plants with a consequent reduction in revenue. (True, 1932, p. 144) The damage to truck crops in general only affects that season's crops.

Vineyards: Damage to vineyards is a combination type of damage. The leaders or young terminal shoots of the young plants as well as of the older plants are eaten. When the



. Figure 2. Grape vine showing complete removal of leaves and some damage to berries. Vineyard of Guiseppe Luchesi, northwest of Yountville, Napa County, California. (Photo by courtesy of Dr. T. I. Storer and taken by him October, 1930)

vine is defoliated by deer there is a loss of production for that year, and if continued defoliation occurs, the vine may die, or be stunted seriously enough to render it useless economically. See fig. 2. If the vines are defoliated in the spring, the flower cluster is destroyed and the crop for that year is destroyed also. If the vineyards can be protected during the early part of the growing season, serious damage may be reduced, because as the leaves of the vine become mature, and perhaps less palatable, deer damage from vine defoliation decreases considerably. Defoliation does not stop entirely and may be evidenced through the entire summer and early autumn months. The grapes (berries) are eaten by deer through the entire growing season until the grapes are finally harvested in the fall. See fig. 3. Many ranchers state that deer seem to walk through a vineyard taking a mouthful of grapes from one vine after another, not stopping at one vine to obtain their evening or morning meal, but eating more or less on the move. Other observations indicate that deer prefer the more tender part of the grape-bunch and nip off the bottom ends of the bunch, leaving the top part of the bunch un-marketable in many cases. When vines are defoliated by deer earlier in the summer the remaining berries, if not eaten by the deer, will be sun-burned and their growth will be stunted or they will shrivel up entirely, thus there is a definite crop loss in either instance.



Figure 3. Grape vine showing severe damage to berries and the partial defoliation of the vine. (Photo courtesy of Tracy I. Storer)



Figure 4. Portion of vineyard in Napa County showing how natural habitat was replaced by an agricultural crop, resulting in groups of vines eaten back or killed by deer. (Photo courtesy of Tracy I. Storer)

Forage Crops: Damage to crops such as alfalfa, clover and other pasture crops is simply a matter of deer removing feed that could otherwise be used to feed cattle or sheep. In some areas deer annually remove tons of alfalfa and other hay crops and farmers have had to abandon the growing of such crops until they could build adequate fences to protect themselves and their crops. It is the opinion of the writer that deer will not do extensive damage to other crops as long as they have access to pasture crops, particularly alfalfa and clover which is kept in an attractive condition by irrigation. A rancher visited during this investigation in Lake County said it was unwise for a man to plant alfalfa in an area where large numbers of deer were present unless he erected an eight foot high deer-tight fence and patrolled it well during the dryer months, as the deer would search a long time to find a hole in the fence which they could squeeze through to get to this "ice cream" plant.

Cereal Crops: Deer damage wheat, barley, oats and other grain by eating the heads of the grain before the grain matures, and by knocking the grain down by walking and rolling in it. Damage occurs mainly when the heads of the grain are green and contain a great deal of moisture. After the grain matures and becomes dry, the deer turn to other crops or even return solely to their natural diet. This type of damage is not extensive as most of the grain grown in

California is grown in areas where deer populations are low.

Flowers, Shrubs, and Gardens: In counties such as Alameda, Contra Costa, and Marin where there are large numbers of deer living in thickly settled areas, many complaints are received from owners of private homes and nurseries. The deer in this area have become semi-domesticated in a sense and will approach private gardens in broad daylight to obtain a meal of flower blossoms, rose bushes, hedges, shrubs, gladiola tops, beet and turnip tops, lettuce and anything they may find to their liking. In some cases damage was done by deer tramping over newly planted lawns. Areas like this are unique in that most of the land is posted "no hunting" and in the areas where such signs are not posted, the human population is too heavy to allow the hunting of deer during the legal hunting season. Today these areas constitute a large part of the deer damage problem.

Nurseries and Forest Plantations: Some damage occurs to the young shrubs, flowers and young trees that are being grown by commercial nurseries for sale to the public. Here as in the private gardens, damage consists of the deer eating the tops off the flowers, eating the leaves and small branches of the young trees and a general "pruning" by the deer is done to most of the shrubs such as Veronicas, Buddleia, Abelia, Cottoneaster, Pyracantha, Loganberries, Blackberries, Roses and others. In some parts of the state

damage by deer is an annual occurrence on cultivated seedling forest plantations where attempts are being made to establish adequate watersheds and to reforest logged off and burned over areas. This damage consists of the deer eating the tips off the trees and off the small branches. According to a report by True (1932) damage also occurs by the deer trampling and rolling and by making runs through the forest plantations. In some instances, these plantations are so thoroughly damaged that the entire area must be replanted.

Competition Between Deer and Livestock: In many areas of California competition for natural pasture and forage exists between deer, sheep and cattle on National Forest grazing areas and on private land. In these areas where livestock and deer include the same plant species in their diet, ranchers claim that deer reduce the available food supply to such an extent that it is necessary for them to reduce the number of livestock, or to increase supplemental feeding. Naturally the farmer does not want to take either of these measures and a complaint is registered with the California Division of Fish and Game. However, it is rather difficult to estimate damage done to grass and browse species and this type of damage is not often recorded. In a few areas of the state, such as the winter range of the interstate deer herd in Modoc County, the combined feeding activities of both

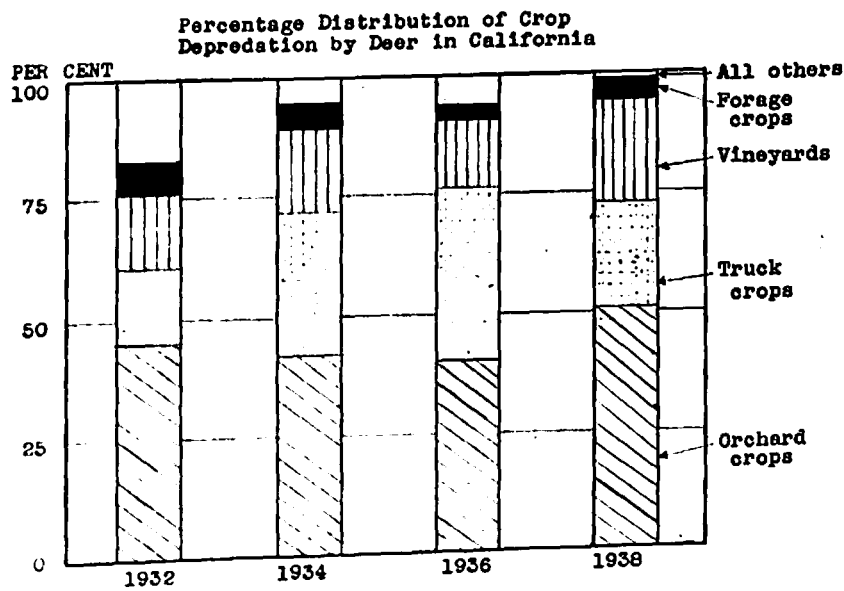
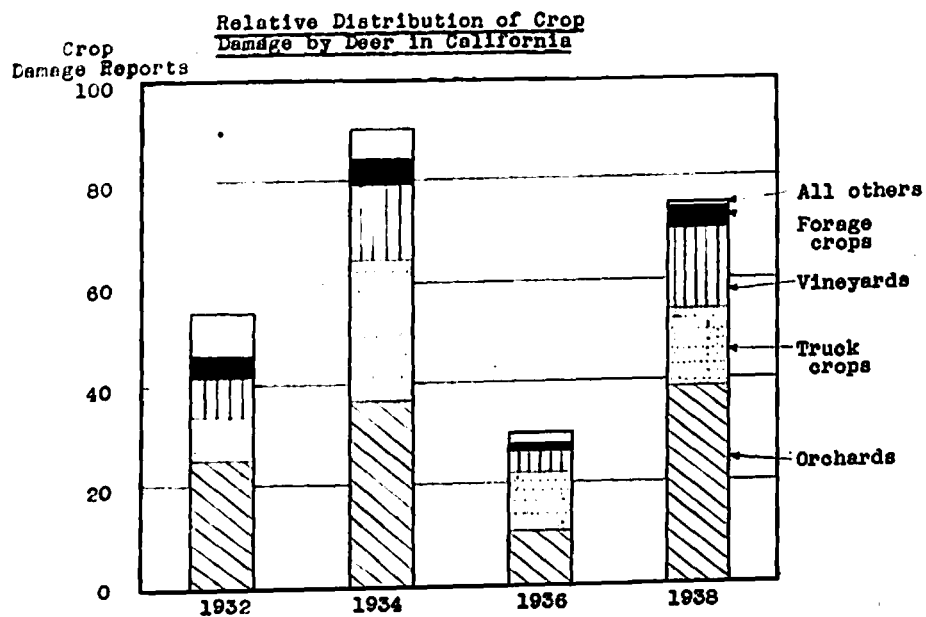
Mule deer and cattle have resulted in severe damage to many parts of this range. Damage to the native browse species in this area increased to such an alarming extent that in the fall of 1945 a cooperative study of this interstate herd and the range it occupied was begun. This herd spends the summer in Oregon and migrates into California for the winter. Because of this the Oregon Game Commission, the U. S. Forest Service and the California Division of Fish and Game are working together to prevent range destruction as was exemplified by the Kaibab deer herd in Arizona, where the population of deer increased to such numbers that the native browse and grass species were permanently damaged, and deer died from starvation by the hundreds. This Interstate Deer Herd Committee is also trying to benefit by the episode of the Murder's Creek Basin in Oregon where multiple use of the range resulted in a serious problem area due to excessive numbers of deer and livestock and an accompanying increase in range depletion (Einarsen, 1947). Studies of other problem areas in California are now being made under the supervision of Dr. Starker Leopold of the University of California with the cooperation of California Division of Fish and Game.

DAMAGE TRENDS

Today crop damage by deer is reported on almost all crops grown either commercially or non-commercially in the state. See Table 1. In addition to this list True (1932) found that persimmons, olives, cabbage, beets, cauliflower, celery, artichokes, vetch, timothy and sudan were reported as being damaged in a lesser amount.

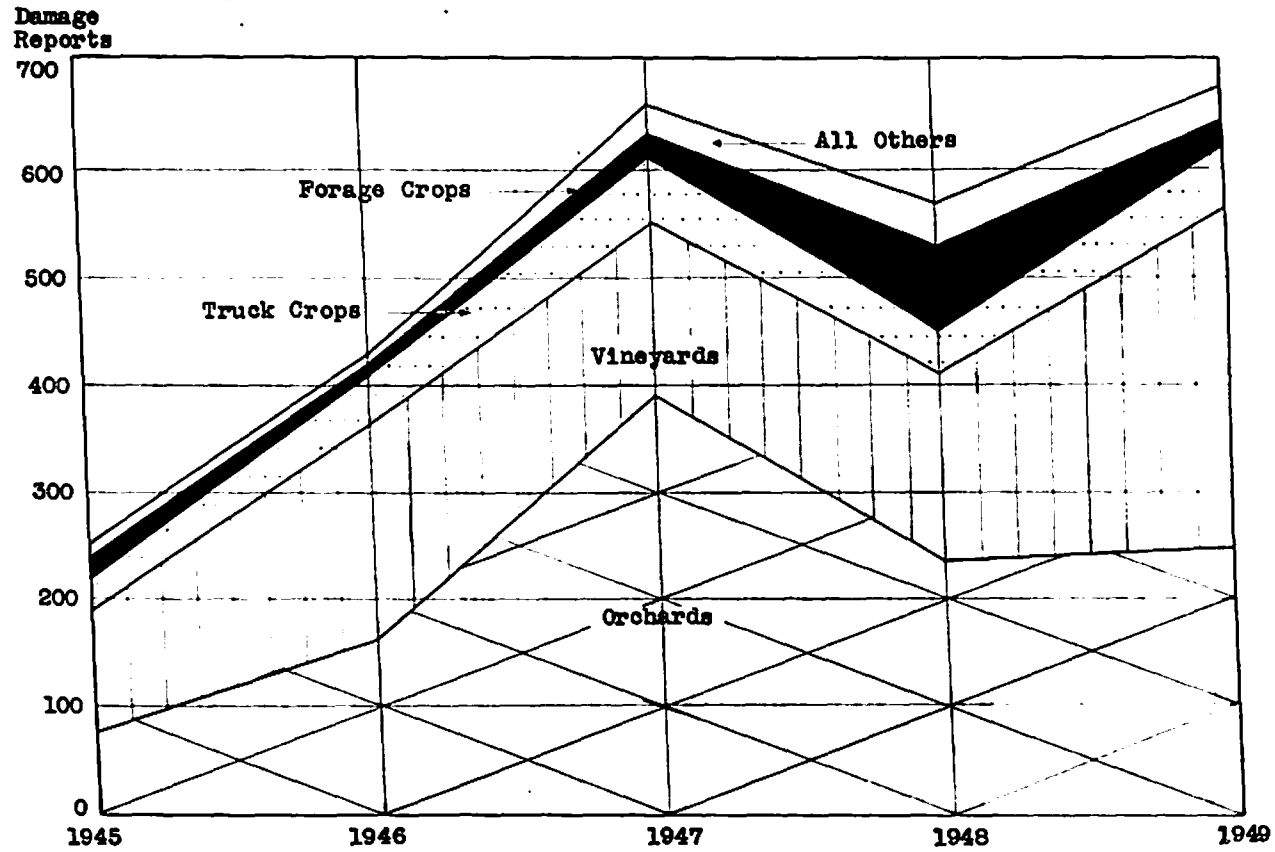
Although the amount of damage on certain crops has decreased one year and increased the next, the most damage has occurred steadily to orchards. See Graph 1. and 2. In 1930-31, True (1932) reported damage on orchards at the top of the list, with truck crops second and forage and vineyard crops almost tied for third place. From 1932 until 1936, orchard and truck crops held their respective positions at first and second, but the damage to vineyards exceeded the damage to forage crops. By 1938 damage to vineyards moved into second place and damage to truck crops moved to third place as is shown in Graph 1. Reliable figures are not available on the type of crop damaged by comparison from 1938 until 1944; however, from 1945 to 1949 reports show that damage to vineyards has moved up and is now challenging orchard damage for first place on the list. See Graph 2.

The total amount of crop damage reported has been increasing at a more rapid rate during the past decade.



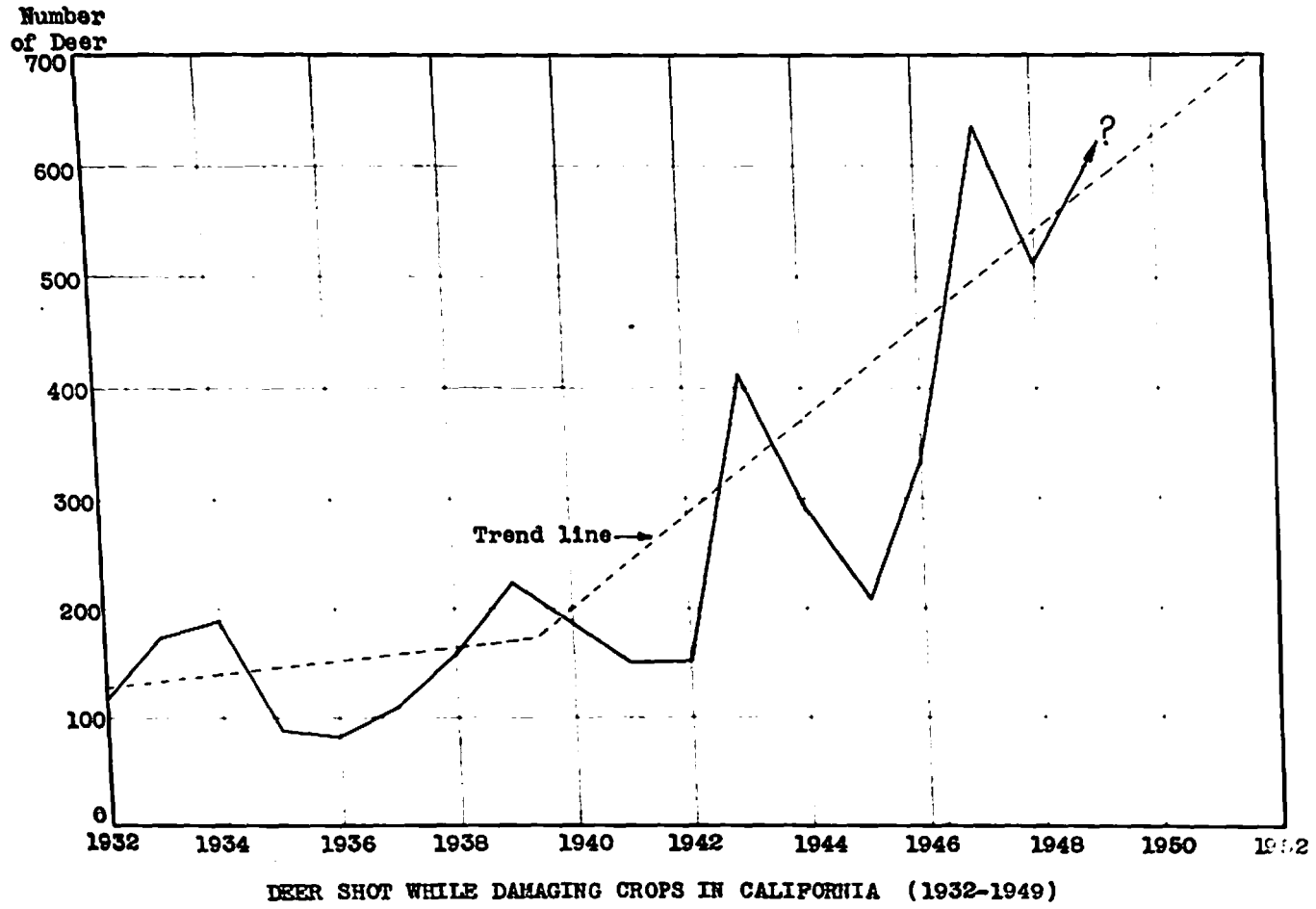
GRAPH 1

GRAPH 2



RELATIVE DISTRIBUTION AND GENERAL TREND OF CROP DAMAGE IN CALIFORNIA FROM LETTERS, QUESTIONNAIRES, AND DAMAGE REPORTS (1945 - 1949)

GRAPH 3



See Graph 3. This parallels the rapid increase of human population in California; and the two no doubt have a very close correlation. Damage is no doubt cyclic as well as seasonal in nature, but the general trend is ever upward. There is a strong possibility that deer damage will be high again this year as the population of deer is still increasing and agricultural practices are likewise increasing to meet the demands of our growing human population.

In reference to Table 1, it should be added that in certain residential areas where permits to kill deer that are damaging crops are not obtainable, large numbers of deer have been causing damage to gardens, shrubs and flowers and to seedling trees and to nursery stock. This damage is not included in this table. It is being at least temporarily solved by the removal of large numbers of deer.

TABLE I

CROPS DAMAGED BY DEER IN CALIFORNIA AS COMPILED
FROM 4,486 DEER DAMAGE KILL REPORTS
(1932-1938 & 1945-1949)

Type of Crop Damaged	Number of Reports
ORCHARD:	
Citrus - - - - -	364
Prune - - - - -	320
Almonds- - - - -	275
Apples - - - - -	73
Pears- - - - -	65
Walnuts- - - - -	30
Cherries - - - - -	42
Avocados - - - - -	27
Peaches- - - - -	20
Apricots - - - - -	18
Total - - - - -	<u>1234</u>
VINEYARDS:	
All Varieties- - - - -	<u>893</u>
TRUCK CROPS:	
Tomatoes - - - - -	65
Beans- - - - -	42
Corn - - - - -	30
Melons - - - - -	19
Strawberries - - - - -	17
Squash - - - - -	14
Potatoes - - - - -	9
Carrots- - - - -	7
Lettuce- - - - -	5
Raspberries- - - - -	2
Truck Crop (misc.) - - - - -	21
Total - - - - -	<u>232</u>
MISCELLANEOUS:	
Gardens- - - - -	89
Cultivated seedling trees & nursery stock- - - - -	76
Flowers- - - - -	24
Shrubs - - - - -	21
Chestnuts- - - - -	2
Total - - - - -	<u>212</u>
PASTURE CROPS:	
Alfalfa- - - 143	
Clover-- - - 16	
Hay - - - - 7	
Total- - - <u>166</u>	
GRAIN:	
Wheat - - - - -	18
Barley- - - - -	12
Oats- - - - -	3
Total - - - - -	<u>33</u>

EXTENT OF DAMAGE

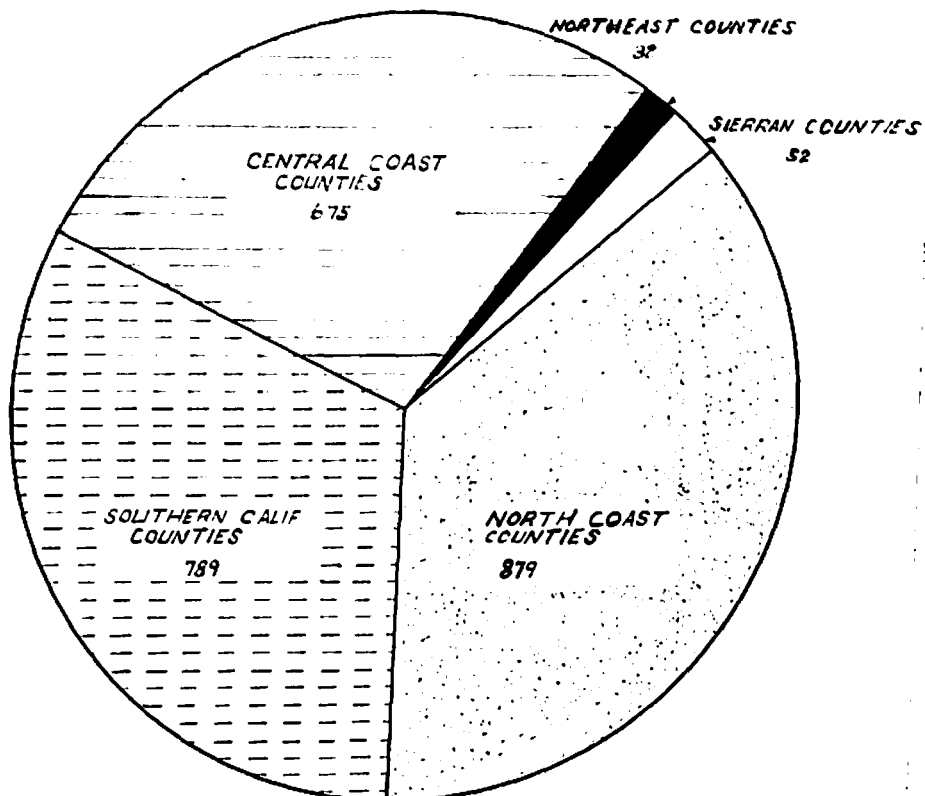
The two sub species of deer found in California are the Columbian black-tailed deer Odocoilleus hemionus columbianus (Richardson) and the mule-tailed deer Odocoilleus hemionus hemionus (Rafinesque). The range of the two sub species is approximately 80,000 square miles or 51 million acres which is slightly more than half of the state. In 1930 and 1931 deer damage occurred in forty-three out of fifty-eight counties. Those counties having little or no difficulty were Del Norte, Lassen and Plumas to the north; Sutter, in the Sacramento Valley; San Joaquin, Stanislaus, Merced, Kings and Kern, in the San Joaquin Valley; San Francisco and Contra Costa, in the San Francisco region; Mono, Inyo and Alpine, in the southern Sierras; and Imperial County in the far south. (True, 1932, pp. 137-38.) See Map 1. Today the area of damage is somewhat extended and damage has been reported in the above counties to a greater extent and has been reported to two more counties, Contra Costa and Lassen counties. The probable reason for damage not occurring to any great extent in some counties is two-fold. The first being the fact that in many areas deer are very scarce where crops are grown, such as in the San Joaquin and Sacramento Valley, in the north and central part of the state and in the Imperial Valley in the south. The second fact is the reciprocal of the first, that is

there are many areas of the state where no agricultural crops are grown such as the high mountain areas of Inyo, Mono, Alpine, Del Norte, Humboldt, Trinity and Siskiyou counties, to mention a few.

The fact that only two counties were added to the list after 1930 shows that the deer damage pattern for the state was established fairly well by that time. Since that time we have had a tremendous increase in agricultural practices and hence an increase in damage in those areas where deer abide. It is interesting to note how the damage has increased more in some areas of the state than in others. Deer damage reports show that the increase has been from the southern counties to the north coast counties. This may be partially explained by the large increase in population of the more northern sections where there are larger numbers of deer. While Graph 4. shows an over-all picture of damage for a period of 12 years, the transition has been from one part of the state to the other.

The extent of damage varies from year to year in many areas of the state. Today there are recognized "hot spots" where populations of deer have increased so rapidly as to cause damage not only to agricultural crops but to their own native habitat as well. Dr. Starker Leopold of the University of California is now supervising a special study of deer ranges in California in regards to areas where deer populations seem to have exceeded the carrying capacity

STATEWIDE DISTRIBUTION OF
DEER SHOT DAMAGING CROPS IN
CALIFORNIA OVER 12 YEAR PERIOD



This graph shows the distribution of 2,427 deer that were shot while damaging crops to serious extent. This includes both male and female animals and a few unidentified young animals.

GRAPH 4

of their range. In reference to agricultural crops, however, the main "hot spots" today are in the Capay Valley, Yolo County; in the Auburn area of Placer County; in Priest Valley, Monterey County; Modoc County which is a perennial headache; home gardens of Marin, Alameda and Contra Costa Counties; the ever-present area of damage in the Napa Valley; and in the Ojai and Piru section of Ventura County.

North Coast Counties:

- Humboldt - Annual damage to apple orchards and to truck crops, particularly to corn. Some damage is reported on alfalfa and clover.
- Mendocino - Annual damage to apple, pear and prune orchards, and extensive damage to vineyards. Periodic reports of damage on shrubs and truck crops.
- Napa - Extensive damage annually to prune orchards and vineyards, with some damage on truck crops. (Cornett, G., Agricultural Inspector, Letter of Feb. 14, 1950)
- Contra Costa - Damage to new lawns and gardens in residential home areas. Damage to orchards and forest plantations.
- Sonoma - Vineyard and orchard damage very heavy. Prune trees being the principal orchard crop damaged. Damage to truck crops is also reported but in lesser amount. Damage estimated to be between \$8,000 to \$10,000 annually. (Office of the Agriculture Commissioner, Letter Feb. 16, 1950)
- Lake - Annual damage to alfalfa, orchards and a variety of truck crops, vineyard damage is reported to a lesser extent.
- Marin - Deer damage is extensive in ornamental gardens and home orchards. Artichoke and pea crops suffer serious damage and some hay crops. Damage estimated to be \$5,000 to \$10,000 annually. (Peryam, T. W.)

Agriculture Commissioner, Letter April 17, 1950)

- Solano - Extensive damage is reported to cherry trees and some damage to prune trees in Green Valley and Suisun Valley. (Pohl, G. A., Agriculture Commissioner, Letter March 21, 1950)
- Yolo - Very serious annual damage occurs in the Capay Valley on almond trees, with some damage reported to prune orchards, grain, alfalfa and truck crops.
- Alameda - Damage occurs to private gardens in the hill area from San Leandro to Mission San Jose; and in the vicinity of Sunol and Pleasanton. Damage is reported to many vineyards and a few orchard and truck crops. (Laing, G. A., Agriculture Commissioner, Letter Feb. 24, 1950) Forest trees (seedlings) are also damaged.
- Colusa - A small amount of damage occurs to vineyards and orchards located in the foothills.
- Glenn - Ranchers near Stonyford had to give up raising alfalfa as the deer were getting the later cuttings. Near Elk Creek and Newville deer eat nearly two-thirds of the alfalfa crop. Some damage to wheat and barley is also reported. (Lundeen, N. L., Agricultural Inspector, Letter Feb. 24, 1950)
- San Mateo - Damage occurs to private gardens and orchards, with some damage to truck crops. Damage here is not serious.
- Trinity - Some damage is reported to alfalfa, grain, shrubs and flowers, with most damage occurring to alfalfa.

Central Coast Counties:

San Benito- Some damage to vineyards and orchards.

Santa Cruz- Damage to young orchards and vineyards in the hilly areas of the county. Estimated annual damage is over \$3,000. (Rebuffo, R., Deputy Agriculture Commissioner, Letter Feb. 17, 1950)

- Santa Clara - Annual damage to prunes, apricot, vineyards and truck crops, with vineyards and prune damage being very heavy.
- Monterey - Most of the damage occurs to orchards, vineyards and truck crops, mainly tomatoes.
- San Luis Obispo - Damage occurs to orchards, vineyards, gardens and truck crops, mainly potatoes.
- Santa Barbara - Extensive damage to orchards, alfalfa and truck crops, mainly field beans; and some damage to grain fields. (Cummings, W. S., Agriculture Commissioner, Letter, Feb. 16 1950)

Northeastern Counties:

- Modoc - Annual damage to vineyards, pasture crops, grain truck crops and native pasture. (White, L., Agriculture Commissioner, Letter April 13, 1950)
- Lassen - Annual damage to alfalfa hay, pasture and cereal grains. Heavier damage to hay stacks in years of heavier snow-fall. (Fix, E. E., Agriculture Commissioner, Letter April 3, 1950) Estimated damage is \$3,500 each year.
- Shasta - Mountain meadows in alfalfa are severely damaged each year and some damage to apple orchards. Damage occurs also to truck crops, mainly strawberries, and to private gardens in the mountain districts. Damage is estimated at over \$15,000 annually. (Stroup, B. F., Agriculture Commissioner, Letter Feb. 17, 1950)
- Siskiyou - Damage occurs to grain, alfalfa and truck crops. Damage is estimated at approximately \$10,000 each year. (McKinney, J. O., Agriculture Commissioner, Letter Feb. 17, 1950)

Sierran Counties:

- Tulare - A small amount of damage is reported on citrus fruits and vineyards.
- Eldorado - Extensive annual damage to orchards, mainly apple and pear trees, and field crops. In

1950 a survey made by Ivan Lilley, Farm Advisor, showed a loss of \$66,000. (Nobley, Agriculture Commissioner, Letter Feb. 11, 1950)

- Plumas & Sierra - Damage is confined to spring range, alfalfa, grain and some garden damage. (Young, A., Farm Advisor, Letter Feb. 14, 1950)
- Placer - Some damage occurs to pasture crops, orchards and truck crops. Damage not serious.
- Amador - Damage to vineyards and orchards most commonly reported. Damage not serious.
- Nevada - Damage to vineyards, truck crops and orchards. Damage is not too heavy.
- Tehama - Some damage occurs to pasture lands and to orchards in the foothills. Damage is estimated at around \$1,000 per year. (Ancell, S. T., Agriculture Commissioner, Letter April 1, 1950)
- Butte - Some damage occurs to alfalfa, orchards and vineyards.
- Mariposa - Damage occurs to orchards, mainly citrus, and a few truck crops. (County Farm Bureau, Letter April 5, 1950)
- Tuolumne - Most of the damage occurs north and east of Sonora to orchards. (Sherrard, H. H., Agriculture Commissioner, Letter March 3, 1950)

Southern California Counties:

- Inyo - Damage confined to young orchards. This is not very serious in this county. (Shebley, H. V., Game Warden, Letter Feb. 12, 1950)
- Ventura - Very extensive damage occurs to citrus fruits, and some damage to other orchards, vineyards, alfalfa, and truck crops, mainly squash. (Barrett, C. J., Agriculture Commissioner, Letter April 4, 1950)
- Los Angeles - Deer do some damage to orchards and yard-plantings in the foothill area, but the most serious damage occurs to citrus and

other orchard trees, vineyards and truck crops. (Becker, E. M., Agriculture Commissioner, Letter Feb. 25, 1950)

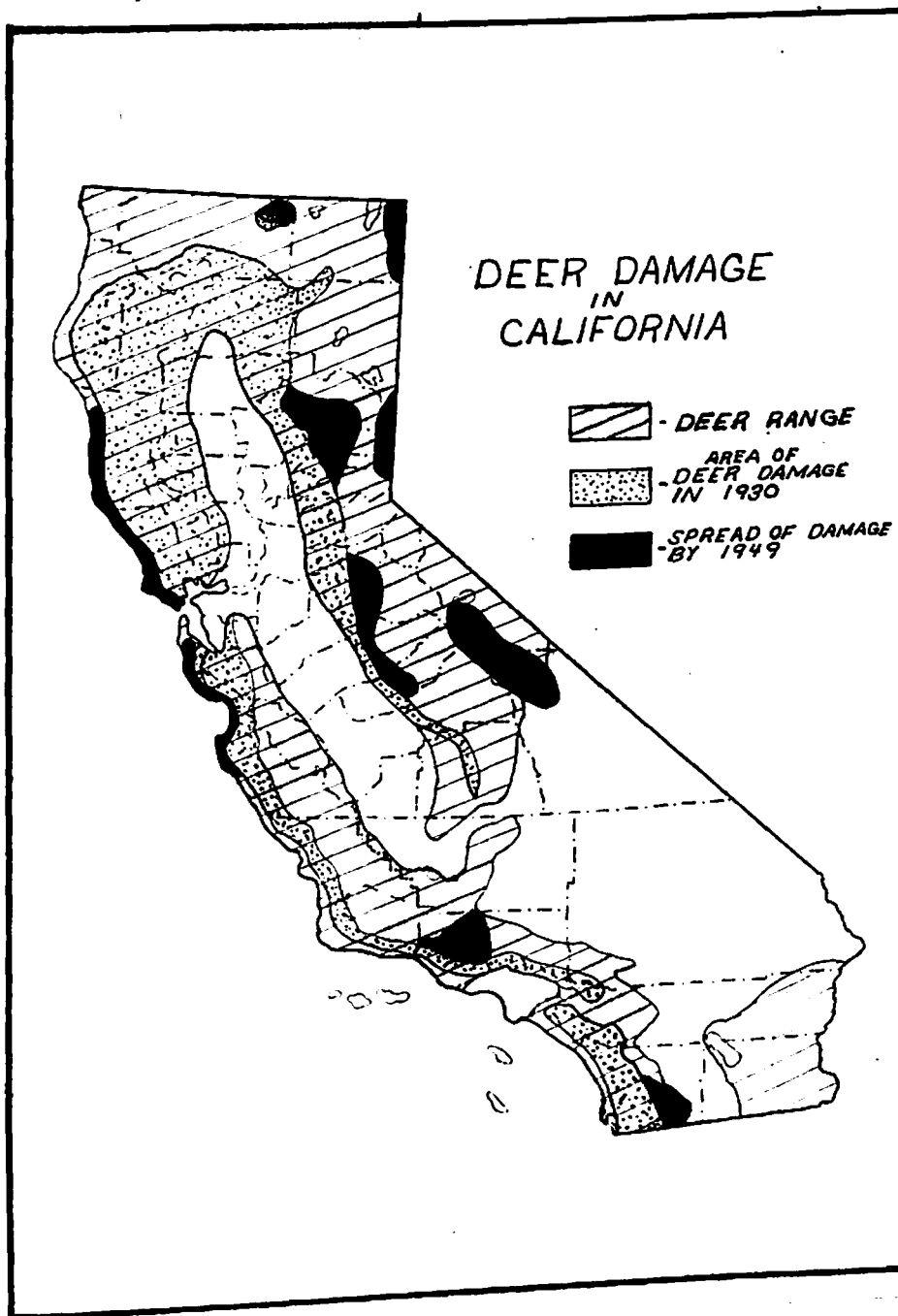
Orange - Damage occurs to young citrus trees and truck crops, mainly blackeye beans in the hills east of Santa Ana. (Dudley, E. A., Deputy Agriculture Commissioner, Letter March 13, 1950)

Riverside - Damage occurs to young citrus, peach and apricot orchards, vineyards and alfalfa. (Wright, W. H., Agriculture Commissioner, Letter Feb. 16, 1950)

San Bernardino - Annual damage to vineyards and orchards, mainly citrus and apple trees. (Crane, H. A., Agriculture Commissioner, Letter March 13, 1950)

San Diego - Damage occurs to vineyards, truck crops and orchards, mainly citrus and avocados.

Other counties experiencing only minor periodic damage are omitted.



MAP 1

CAUSES OF DAMAGE

The primary cause of crop damage by deer in California is increased agricultural activity and the decrease of natural deer habitat. This is elementary to be sure, but it is the foundation for all crop damage no matter what type of crop or what type of animal is considered. According to an economic survey made by the California State Chamber of Commerce (1949) there were less than one million people in California in 1880, half of whom lived in rural areas. At this time deer damage was probably nil. By 1900 the population had reached one and a half million, half of whom lived in rural areas. Between 1900 and 1920 there is reason to believe that deer damage came to the fore. By this time there were three and a half million people living in California; one million of them were engaged in agricultural practices of one scale or another. The combined activities of the agricultural population, who were busy clearing and planting land, together with the expansion of the cities into semi-wild country produced a rapid decrease in the available habitat and natural food for our native deer. This decline in natural habitat continued as the population increased to over five million people in 1930 and seven million in 1940. We have more than doubled our population in twenty years and today, 1950, there are approximately eleven million people in our state.

As the population increased, the demand for land and the acres under cultivation increased; the deer were forced to turn to commercial crops as a supplement to their rapidly decreasing natural forage. The value of fruits and nuts produced in 1948 is 145% greater than that of 1940, while the value of field and truck crops in 1948 increased 270% and 198% respectively over 1940. According to the 1945 Census of Agriculture there were 138,917 farms in California, embracing 35,054,000 acres of land. Of this, 11,363,000 acres was designated as crop land, the rest being mainly pasture lands. With 51,000,000 acres of deer range, and 35,000,000 acres of crop and pasture lands in an area of less than 100,000,000 acres, which is the approximate size of California, the two are bound to meet. It is where they do meet that the deer damage problem is in evidence.

Water:

As the demand for land continued, it became economically sound to farm more extensively. In many cases this meant draining marshes, plowing further up on the side-hills and bringing water to areas of drought. The demand for water was increased as California was developed; farmers became water-conservation conscious; they tapped most of the available springs and built cities and parks around water areas, such as lakes and streams. This made it difficult for deer and other animals to obtain water in those regions

where most of water was brought under man's control. As the hot, dry months came around, the deer turned to the succulent crops of the farmer to obtain part of their daily requirement for water. Thus water has a very important part in this problem and will be discussed later in another section.

Deer Population Has Increased:

Although the natural habitat of the deer has suffered from the activities of man in many sections of California, there are other sections where the habitat has been actually greatly improved for deer. This is true particularly in the forested areas where logging activities have removed heavy stands of timber and have burned over millions of acres of land that were once densely covered by trees and brush, thus allowing the young plants and even grass to become a dominant part of the landscape at least for a few years. This young growth has been found to be of very high nutritional value, and has resulted in greater productivity in the deer herd. It is a common practice in many areas where the raising of livestock is practiced, to burn the brush off the forested land to provide for more and better feed for their livestock, and consequently for the deer. With this increase of natural forage and with the addition of the feed supplied by the farmers' crops, perhaps, in some areas the diet of the deer has become better balanced and highly nutritious. This has resulted

in a higher productivity of the herd probably due to these

- factors:
1. Higher fertility of male deer.
 2. Lower frequency of abortions.
 3. Increased amount of twinning.
 4. Fewer deaths from malnutrition and diseases.

If we transfer what we know about mammalian embryology and physiology in general to the deer herd, it is logical to expect these things to result from a diet of higher nutritional value.

Game laws have also aided in the population increase. As the population of California increased, the hunting pressure on our wildlife assumed dangerous proportions. It soon became evident that unless some protection was provided for our rapidly diminishing game animals, particularly deer, it would be a matter of only a few years until wild game would be a memory of the past. To prevent wildlife in California from following the road taken by the Labrador Duck, Heath Hen, Passenger Pigeon and many others which are now extinct, game laws were passed to establish open and closed seasons and to regulate the maximum take of any one game species. Predatory animal control was affected to decrease the natural enemies of our wild game. Bounties were placed upon our mountain lions, Felis concolor californica May, our wildcats or bobcats, Lynx rufus Merriam, our coyotes, Canis latrans and others. The deer along with other species of wild game have responded very successfully to our efforts toward their conservation. From a low

reported kill of between 3,000 and 9,000 in 1914 and 1915 (reporting kill was not compulsory), the number has increased to 19,500 in 1927 when reporting kill was made compulsory, and to 47,000 in 1947; and today the population of deer is believed to be at an all-time high. Leopold (1933) found that for each legal buck taken in New Mexico there were 24 other deer. From census studies made by the U. S. Forest Service in California forests after 1940 a figure of 1 legal deer killed to 14 other deer was derived. This gives a total population of approximately 705,000 based on the 1947 reported kill. According to estimates made by the University of California deer study, the present population is approximately 1,000,000. Other estimates made by wildlife biologists range from 700,000 to 1,000,000. The important thing is that the deer population is believed to have more than doubled in California; and in areas where crops are grown, this increase in deer numbers has accounted, in part, for an increased deer damage problem. Map 2. shows the distribution of the 47,000 deer killed in 1947. Compare this with Map 3., showing the distribution of deer killed on crop damage permits in 1947. It may be seen that there are many deer killed in the legal hunting season in the same areas classified as "hot spots" such as is represented by heavy concentrations in Ventura, Napa, Yolo, Sonoma and Monterey counties. It also can be seen that in many high mountain areas the number of deer killed by hunters is

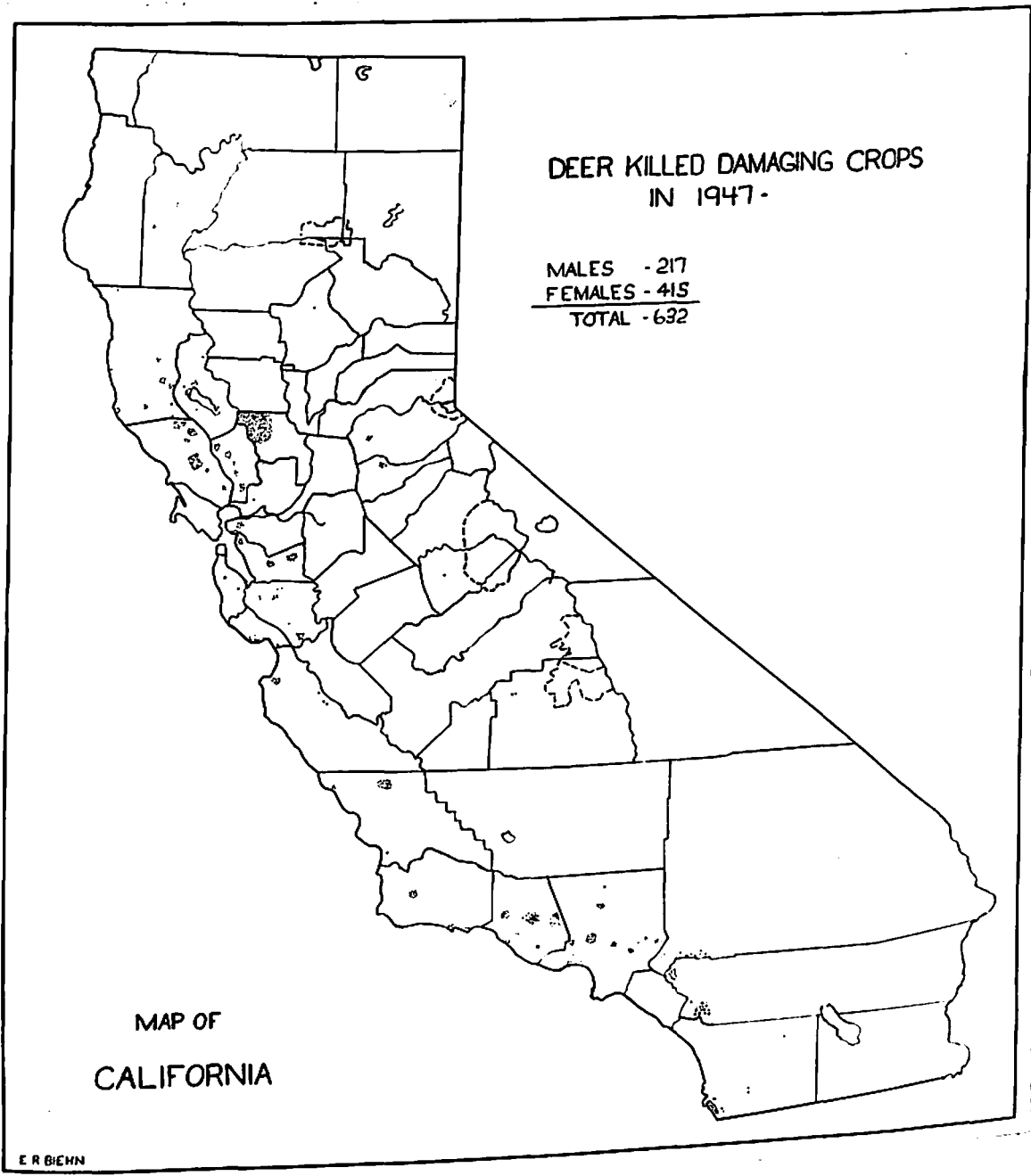


MAP 2

large, while in the same area there were no deer killed while damaging crops, mainly because these are not agricultural counties. There is a certain amount of error introduced when this sort of a comparison is made and allowances must be made for such error, for instance, in certain sections of the country such as Modoc and Lassen counties in particular, the farmers do not ask for permits to kill deer when they are damaging crops as they feel that the damage caused by deer does not amount to more than the value of the deer to them. They would rather share some of their crops with the deer in the spring and summer in hopes of getting a fair economic return during the hunting season. This factor may be applied to most of the state and must be kept in mind when analyzing data obtained from deer damage kill reports. However, there is a fair amount of accurate information from this source as it tends to show the areas where the damage by deer is greater than the aesthetic or sporting value of the deer to the farmer, and these are the areas of most concern in this paper.

The cause of deer damage in some local areas may be due to any one of these factors previously mentioned, but in most cases in California it has been the result of the inter-action of all these factors, each contributing a part to the over-all picture. The main causes are simply these: (1) Decrease of natural deer habitat. (2) Increase of agricultural practices. (3) Shortage of water on the deer

range. (4) Increase in deer numbers brought through predatory animal control and game law legislation.

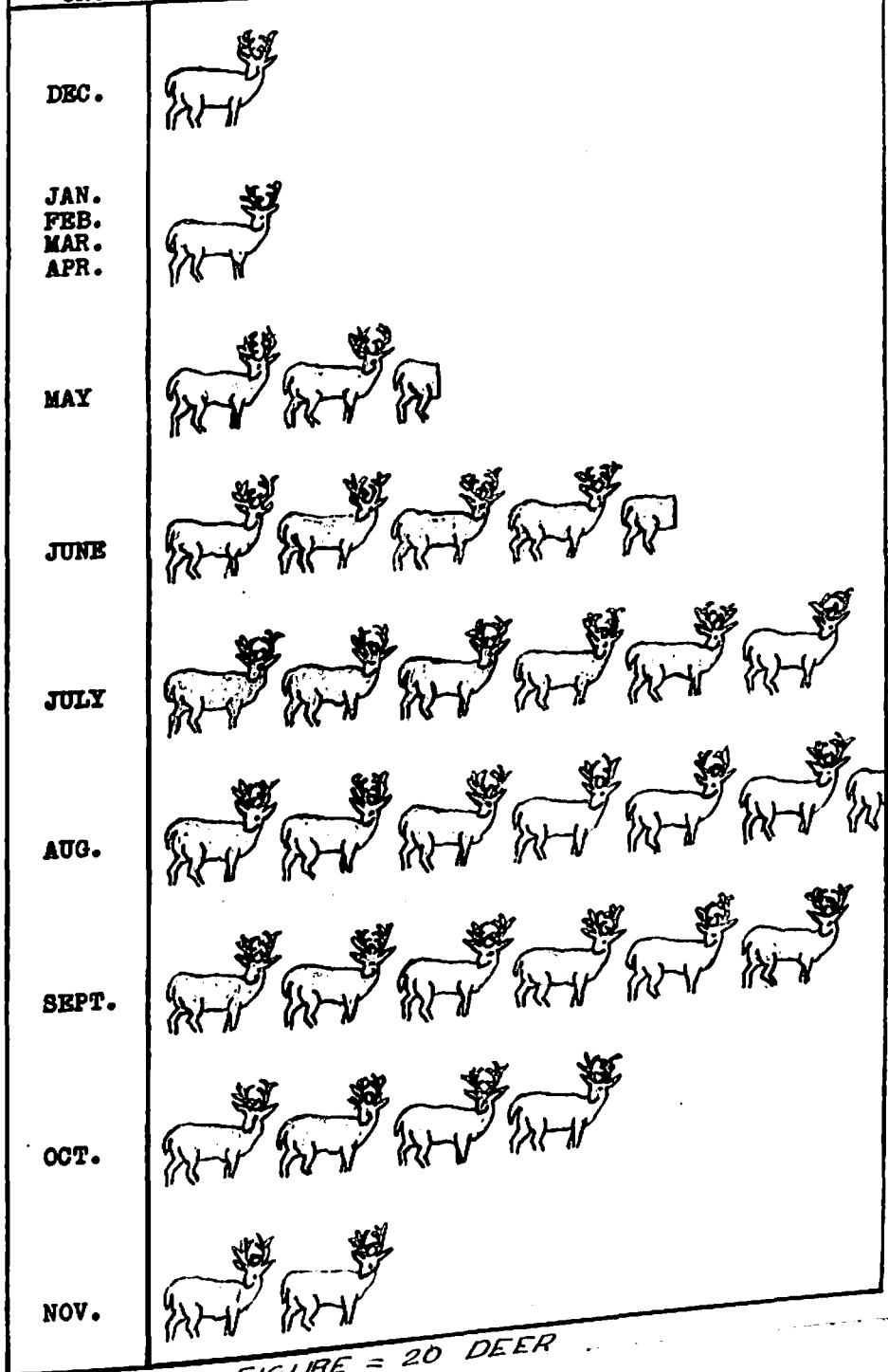


MAP 3

SEASON OF DAMAGE

It is impossible to select any one month of the year as the month when damage to crops is highest and apply the month selected to all areas of the state and to all types of crops. However, for the entire state, crop damage seems to follow the same general pattern for the majority of the crop-types. Graph 5. shows the seasonal distribution of damage over a six-year period 1932-1938. If these were analyzed and graphs made of each year, each graph would be almost an exact miniature of the total. This graph was plotted from 1935 to 1949 to see if there was any change in the seasonal distribution of crop damage from one year to the next. See Graph 7. Data compiled from deer damage shooting license tags and from questionnaires show that the pattern of seasonal damage shown in Graph 5. is true of the entire period from 1932 until 1950. So close does this follow this general pattern that any figures may be substituted for the value of each symbol of deer shown in Graph 5. and the true picture would not be altered to any serious extent. The over-all picture from 1932-1950 shows the month of August as having only 5% more damage than July and 15% more damage than the following month of September; but the general picture remains about the same in both cases with most of the damage occurring during the summer months. Damage is at its lowest in the winter and early

DEER SHOT WHILE DAMAGING CROPS IN CALIFORNIA OVER
A SIX YEAR PERIOD SHOWING SEASONAL DISTRIBUTION OF
CROP DAMAGE

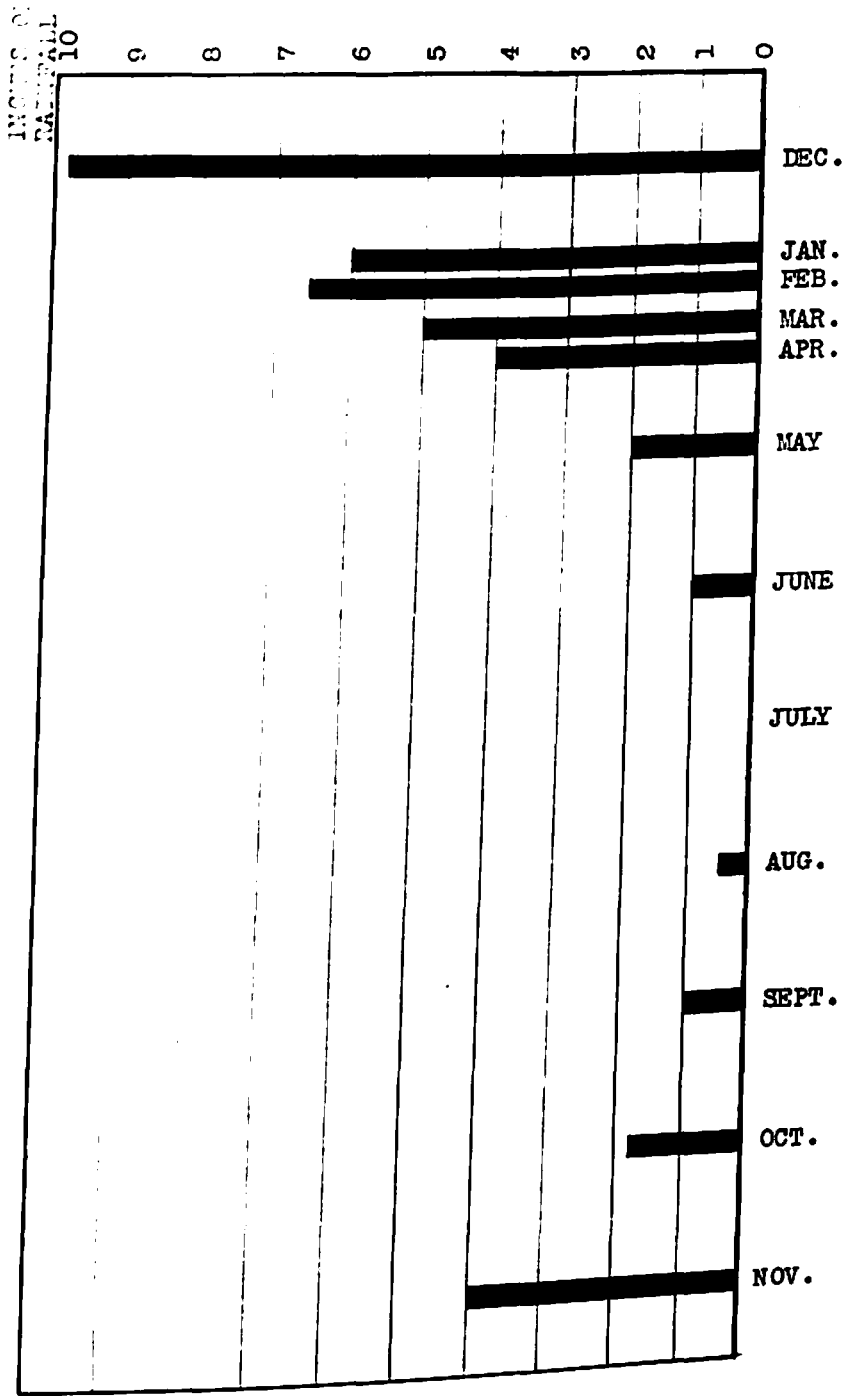


1 FIGURE = 20 DEER

GRAPH 5

spring months, and steadily increases during and runs parallel to the growing season.

It has been previously pointed out that the amount of water that is available throughout the year has a very important part in determining the amount of damage during the year. For illustration of this point a graph has been made, Graph 6, of the average annual rainfall in Sonoma county where annual crop damage estimates of over \$10,000 have been made. The seasonal distribution of damage in Sonoma follows the general pattern of damage shown in Graph 5. By superimposing the rainfall distribution of Graph 6 on the damage distribution graph, it can be readily seen that rainfall is, or at least should be considered as a major controlling factor in the seasonal distribution of damage. During the months of July, August and September when rainfall is at its lowest for the year, crop damage is at its highest for the year, and during November, December, January, February, March and April when rainfall is at its highest for the year, crop damage is at its lowest for the year. In the dry months of the year the natural succulent feed of deer is at a minimum; it is a time when the water content of grass and browse is at a low level, and this is paralleled by a lower water supply. Springs that supply plenty of water during the winter and spring begin to dry up and often disappear entirely by July and August, coming back to normal function again in the fall. Knowing these



GRAPH 6
Average annual rainfall of
Sonoma, Sonoma County, California.

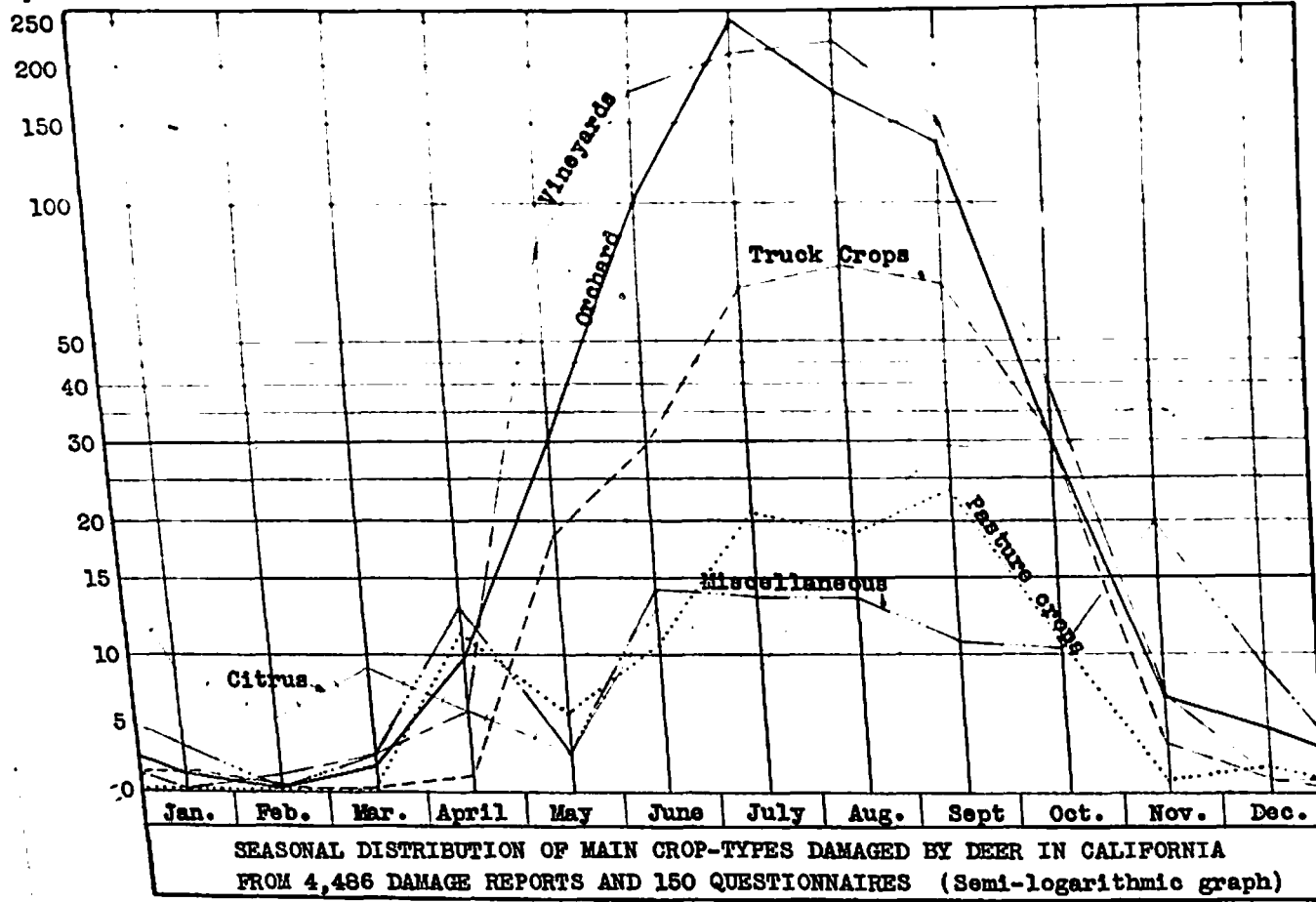
facts then it is logical to assume that the deer would make longer trips; jump higher fences; and take greater risks to obtain more desirable succulent food that has been kept green and high in water content by irrigation in many cases. It should not be concluded that all that has to be done is to supply more watering areas to the deer and damage by deer will be a thing of the past. No, that is not the right assumption either. Perhaps an increase in watering areas and an increase in natural succulent deer food would reduce the amount of damage considerably, but it has been reported that deer will often turn from natural succulent feed to cultivated crops when such crops are easily obtained.

Another factor that affects the seasonal distribution of damage is the seasonal variations of the deer population. The population of deer is the largest during the time of the year when the young are born, which is in May and June. During this time when the fawns are nursing, greater demand is placed upon the female; and consequently, she goes to greater lengths to secure more feed to keep up her milk supply. In a few months the young are able to forage for themselves, thus adding more stomachs to fill with natural or cultivated plants. As the young grow to maturity, more and more food is needed and they accompany the adults to adjacent cultivated fields. By mid-August the mature females and mature males together with the young are

perhaps all relying on that bean field or vineyard for their main source of succulent feed. A large number of male deer are removed during the hunting season in August, September and October of each year. Today approximately 50,000 are taken legally and, undoubtedly, many are taken illegally each year in California. Thus by mid-October the total population of deer has been reduced by over 50,000, which means a corresponding reduction in the demand for natural and cultivated food plants and products. Deer numbers are further reduced by the continuous attacks of natural predators, disease, forest fires, weather and feed conditions and poachers. By the time the next fawning period arrives, the deer population is at its lowest level since the previous fawning period. Thus deer damage is increased when the number of deer-pounds that must be maintained is increased; and the amount of damage decreases when the number of deer-pounds to be maintained decreases. This is an important fact to consider in the management of these species both in agricultural areas and in primitive areas where natural deer range is being depleted by over-browsing.

The seasonal distribution of damage is also affected by the type of crop grown, and upon further study of the data collected it was discovered that the general pattern of damage distribution is followed very closely by four main crop types. These are vineyard crops, orchard crops, truck crops and pasture crops. See Graph 7. It may be

Damage Reports



SEASONAL DISTRIBUTION OF MAIN CROP-TYPES DAMAGED BY DEER IN CALIFORNIA FROM 4,486 DAMAGE REPORTS AND 150 QUESTIONNAIRES (Semi-logarithmic graph)

GRAPH 7

seen from this chart that there are two crop-types that do not follow this pattern as do the others. These are the citrus crops and miscellaneous crops such as flowers, seedling forest trees, private home gardens, shrubs and nursery stock. It is noted that damage to citrus fruit occurs during the entire year and reaches its peak in September, October, November and December, with November being the month of most damage. It can also be seen that damage is least on citrus from February to July. This may be explained by the fact that citrus crops are green the year around, and are available after the other crops have been harvested and before the new crops arrive in the spring. When other crops, such as vineyards, orchards and truck crops are available, deer seem to prefer them and damage to citrus is reduced somewhat. A similar reason may be given for the erratic pattern for damage distribution to miscellaneous crops. This damage occurs mainly in April through November. The sudden decrease in damage reports in the month of May has no explanation except that in the areas where this sort of damage is most prevalent there are a large number of homes and it is during this time of the year that the female deer are looking for a secluded area in which to drop their fawns, thus moving away from the garden areas. This fact may also be responsible for the sharp decline of damage occurring to citrus and pasture crops in May, but there is not sufficient evidence to establish this

at the present time. It is logical to assume that vineyards and orchard crops would be more easily obtained by deer since these crops are often grown in hilly regions and are bordered by brush and forests, while the citrus, flowers, gardens and pasture crops are grown in more settled areas.

In summary, the causes of seasonal distribution of damage in California are these:

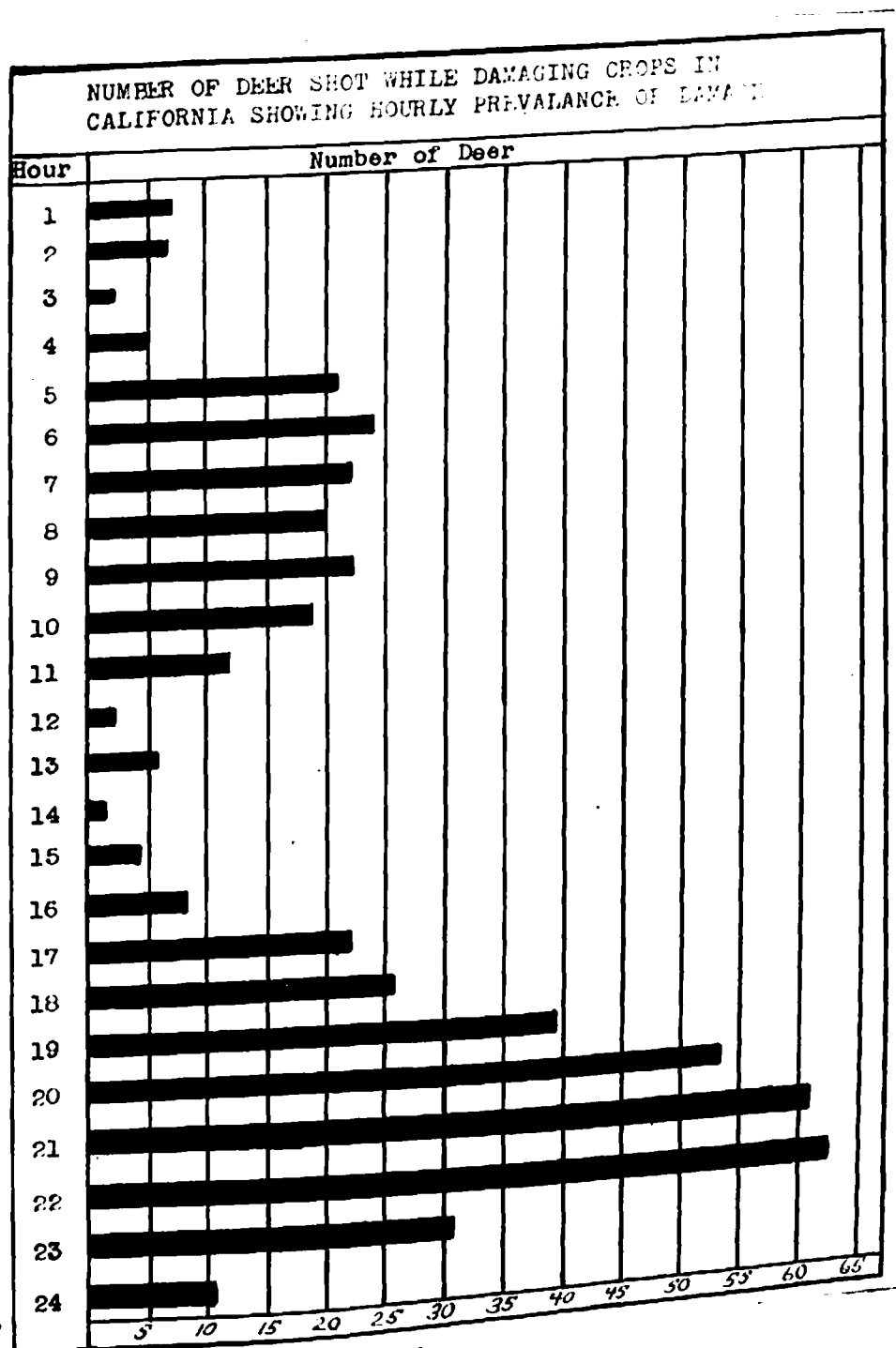
- (1) Amount of rainfall.
- (2) Seasonal fluctuation of deer population.
- (3) Length and time of the crop growing season.
- (4) Type of crop grown.

CONTROL OF DEER DAMAGE

As the problem of crop damage by deer grew larger, it became evident that something had to be done to discourage deer from making these repeated attacks against the farmers. At first many things were tried which met with little success; because of the wide variety of methods used to repel deer and to control damage the writer will present each method separately.

1. Frightening Methods: The natural feeding habits of the deer must be considered in any method of damage prevention. Deer prefer to feed during the early morning hours and again at dusk. Consequently most of the damage occurs during the hours between five and nine in the morning and from p.m. until midnight. See Graph 8. During these hours the deer become quite brave and are very difficult to drive away from the crops. Even when they are completely driven out of a field they will come back sometimes within an hour.

McWhorter (1933) reported that carbide flash guns had been successful in keeping deer out of orchards. This gun cost \$35.00 at that time. The gun operates by dripping water on carbide, thus generating an explosive gas. The gun is set to go off every few minutes or every 30 seconds with a loud explosion and flash of light. The carbide must be renewed every day. One gun is said to protect 1000 trees, by hanging the light in a tree or mounting it on a



GRAPH 8

Hour 1 equals 1:00 a.m.
 Hour 13 equals 1:00 p.m.
 Hour 24 equals 12:00 p.m.

swivel and allowing it to swing in all directions with the wind. In some areas this gun has worked with some success and in other areas, farmers state that the deer soon become accustomed to it and other methods of crop protection were substituted in its stead.

The use of scarecrows, white strips of cloth, bright and shiny objects tied in trees and along fences have not given any permanent relief. Lights of all kinds have been tried, but the deer seem to enjoy eating by "candlelight" so to speak.

True (1932) found that dogs have been used with varying degrees of success, the best results being obtained from a dog that continually ranges the brush around the farmer's land and prevents the deer from bedding down near the crop, be it vineyard, orchard or other crops. If they are not bedded down near the farmer's yard, they will be less likely to enter the farmer's yard, although it has been proven, (True, 1932), that deer will travel many miles each day for a good meal of alfalfa, young orchard or vineyard. So dogs should not be purchased with the thought in mind of reducing deer damage to any great extent or for any length of time.

A farmer in Santa Cruz county even resorted to sleeping in the middle of his fields. Every hour he would wake up and chase the deer out of the field. He said it took a lot of yelling and running and club throwing to drive them

out, only to have them return in a few hours. Various other methods of frightening have undoubtedly been attempted at one time or another, but to the writer's knowledge this type of damage control is not successful.

2. The Use Of Deer Repellents: A repellent is usually something that will repel deer from a crop by its odor or disagreeable taste. Repellents which are usually in a chemical form are sprayed on the crop that is being damaged, or placed near the crop that is being damaged, depending on the material used. Many repellents have been used, and because all of these repellents have been used with some success, they will be mentioned briefly at this time.

- a. Creosote oil - A roll of cheese cloth 4 inches by 24 inches is made and tied twice to prevent unrolling. Then a tablespoonful of creosote oil is poured into the end of the roll and the roll suspended in a tree. This is fairly effective for a short period.
- b. Tar paper cones - These cones can be tied around the branches of trees or vines. (Not recommended)
- c. Blood - This is most effective when applied directly to the foliage, although it can be applied to stakes, tree trunks or by dipping rags in blood and hanging them in the orchard or vineyard, etc. (Fairly effective)
- d. Blood meal, ground meat scrap and digester tankage - May be used as above, either dry or mixed with water.
- e. D4 - This is a commercial deer repellent used as a spray. (Not recommended for California)
- f. Hanging unwashed clothes has been tried in

- orchards. (Results doubtful)
- g. Whale oil soap - Used as a spray. (Effective for a short period)
 - h. Asafoetida - Gum asafoetida is placed in small bags and hung about three feet from the ground in the orchard, or two feet off the ground in a vineyard. One pound to ten trees. (Effective for a short period.)
 - i. Naphthalene flakes - Used in a similar manner as asafoetida, three bags per acres. (Fairly effective for 4-6 weeks)
 - j. Double-strength kerosene emulsion - Used as a spray. (Fairly effective for 2 weeks)
 - k. Sheep dip - Used as a spray, or by soaking wood chips and rags in sheep dip and hanging in vineyards, orchards and gardens. (Fairly effective for a very short time)
 - l. Lion scat - Made into a liquid and sprayed on foliage is very successful but highly impractical as the supply of lion scat is very limited to say the least.
 - m. "Goodrite Z.I.P." - This is a commercial deer repellent spray manufactured by the Goodrich Chemical corporation. The California Division of Fish and Game conducted experiments with this repellent along with others, and found that it is the best commercial deer repellent tested to date.

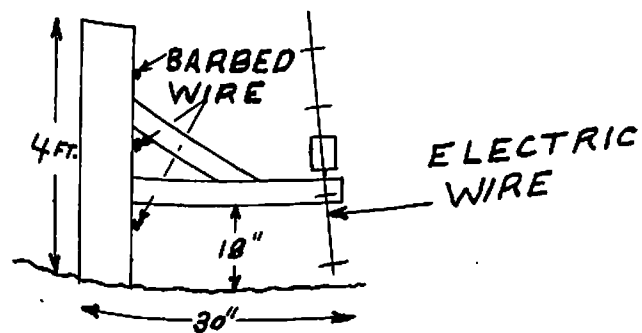
Many of these repellents are good only for a short period of time depending upon the weather. After a rain most repellents are not very effective and they must be applied again for good results. "Goodrite Z.I.P." is fairly effective even after a rain and seems to be the best bet for growers at the present time. The application of any chemical repellent, if used in large quantities will be expensive of course. Even if water were used to spray the

crops, the expense would be great if the area was large. Repellents are more effective on some crops than on others. Spraying of trees such as young almond trees is not practical because the tree grows so rapidly that spraying must be repeated every week or the young shoots will be nipped off as fast as they grow out from the protection of the previous spraying.

3. Fencing: To be sure, if all the areas where damage is being done by deer were enclosed in a standard deer-proof fence, the problem would indeed be solved. Then the question is asked, "Why not build the necessary fences and everyone can get some sleep?" Well, the obvious answer is this: In order for a fence to be absolutely deer-proof, it must have an "effective height" of seven to eight feet. This means that if the fence is on the side of a hill, it must be made higher, depending upon the slope of the hill. A report made by True, Storer and Piper (1952) concluded that a fence constructed to exclude deer should be comprised of woven wire mesh 47 to 55 inches high surmounted by barbed wires at 8 to 10 inch intervals up to the desired height of 7 or more feet. The cost at that time was \$250 a mile for materials. Baade (1931) estimated the cost of a deer-proof fence to total approximately \$1000 a mile including labor and material. The California Division of Fish and Game offered to contribute 90 cents a rod to any farmer who wanted to build such a fence at this time. This offer was

passed up by most farmers who felt that they could not afford the heavy outlay of money necessary for the building of such a fence even with the assistance of state funds. Pennsylvania provides wire and staples for an eight foot fence and the farmer must supply the posts and labor.

Electric fences have been tried with varying degrees of success. An ordinary electric fence constructed to control livestock is not suitable. When deer wish to jump a fence they usually approach it as close as possible before attempting to jump. An ordinary electric fence three feet in height does not do the trick because as the deer receive the electric shock their natural reaction is to jump forward, instead of withdrawing from the fence. When they jump forward they usually go over or under the electric fence. Other types of electric fences have been devised especially for excluding deer. One of these is shown in Figure 5.



A deer coming into contact with the live wire will jump forward only to hit the regular barbed wire. Deer do not like to get between two wires and scramble about for a short time trying to get away. During this time they receive a few additional

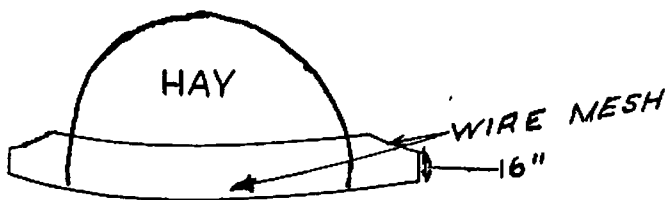




Figure 5. This is a type of electric fence being used to repel deer from commercial crops. (Courtesy Vermont Fish and Game Department)

shocks which they do not relish and will remember for a long while, thus making this type of fence more successful.

Much attention has been given to the fencing of haystacks because farmers seem to be more willing to erect fences around their haystacks, than around entire fields or orchards. Again the ordinary fence of three or four feet is not effective. Fences of 7 or 8 feet in height are necessary and of course of a higher cost. Another type of fence that has been found very effective for protecting haystacks is shown in Fig. 5. It consists of encircling the entire haystack with a four foot wire-mesh fence, and is so constructed as to make it both vertical and horizontal.

Cattle guards leading into any area that is effectively fenced to exclude deer, must be eight to ten feet across, instead of the average cattle guard of five or six feet.

4. Deer Damage Permits: A permit to kill deer that are damaging crops is sometimes issued to farmers who can not protect their crops in any other way. The number of deer to be shot is under the supervision of the local game warden. All deer shot are reported to the warden who will turn the carcass over to State, County or private charitable institutions. A deer damage shooting license tag must be attached to each deer and a duplicate of this must be sent to the California Division of Fish and Game in San Francisco. See Fig. 7. The regulations covering the use of these

PERMIT NO 5523

Permit To Kill Deer Causing Crop Damage

Under the provisions of section 1293, Fish and Game Code—

Mr.

asked me to kill deer upon the property owned, leased or managed by the permittee as described below, and subject to the regulations appearing on this permit.

Description of property to be protected

Location
Area acres
Applicant's estimate of annual deer damage
Warden's estimate of annual deer damage
What crops are damaged
Is property posted
Is the immediately surrounding property posted
Is property fenced
Is property adjacent to a refuge
What control methods have been attempted

REGULATIONS. The permittee and his agents must have a hunting license. Permittee may only kill deer by shooting, and this permit does not void any city, county or state firearm regulations.
Permittee may only kill deer on his property as described hereon, and only when deer are doing, or about to do damage.
Both bucks and does may be killed during the period of this permit irrespective of hours or seasons.
The privilege granted in the permit may not be transferred, and entitles only the permittee, his regular employees who work upon the land described, or member of his family who regularly resides upon said property, to kill deer.
Any deer killed under this permit must be immediately tagged with the special tag furnished with this permit, both tags must be completely filled out, and the duplicate mailed without delay.

The carcass shall be disposed of as follows:

In the event that the above regulations are violated, this permit may be revoked.

Five tags (Nos.) are furnished with this permit. More may be secured upon application to the person issuing this permit.

I have read and agree to the conditions of this permit

FISH AND GAME COMMISSION

Name

By

(DATE)

Address

This permit expires

Hunting License Number

Figure 6. Copy of form to be filled out when applying for a permit to kill deer that are causing damage to crops.

DUPLICATE

Deer Damage Shooting License Tag

No 21746

To accompany Deer Damage Permit No. **7589**

Date **June 22, 1949 11:30PM**

Nearest town and county **Bearmont, Calif. (Riverside Co nty)**

Hour killed **11:30 PM**

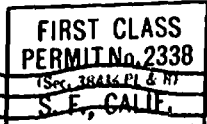
Male or female **Male**

If buck, number of points **2** right **2** left

Crop being destroyed **Young Apple trees**

S. E. Davies, Jr.
Signature of person killing deer
S. E. Davies, Jr.

This tag to be mailed immediately to Division of Fish and Game



**2c.-POSTAGE WILL BE PAID BY—
DIVISION OF FISH AND GAME
510 RUSS BUILDING
SAN FRANCISCO, CAL.**

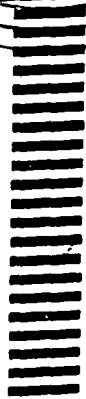


Figure 7. Copy of license tag that must be filled out for every animal killed and returned to Division of Fish and Game.

permits are listed on each permit granted, a copy of which is included in this thesis.

Most ranchers or farmers do not like to use this method of damage control and usually resort to it only when damage becomes heavy and economic losses justify their actions of killing the deer. These deer damage permits are rather difficult to obtain unless the damage can be proven to be exceedingly heavy; and consequently, it is the opinion of the writer that many deer are killed without these permits as well as with them. One farmer in Santa Cruz County admitted killing two deer one year on a damage permit and 13 deer the next year without a permit. Cases like these are not common but it is evident that these measures are being taken by farmers.

In the residential areas of Marin, Alameda, and Contra Costa Counties where damage to private gardens has occurred, deer damage shooting permits can not be used because of firearm restrictions. In these areas it has been necessary for employees of the Division of Fish and Game to shoot large numbers of deer under special conditions.

Shooting deer under the deer damage law is only a temporary control at best. It does not result in any further solution to this problem in California. The farmer does not like to kill the deer; the Fish and Game Commission does not encourage this policy, but rather tries to discourage it; and the sportsmen of our state are certainly

opposed to it. Why then does this out-moded piece of legislation remain in effect? Mainly because if these shooting permits were not available, the farmers would shoot the deer anyway, and a great amount of valuable deer meat would be allowed to lie in the sun to spoil. Under present laws most of the deer shot are utilized by charitable institutions or destitute families. It is the opinion of the writer that until other laws are passed that will reduce deer damage more effectively, the deer damage shooting permits should continue to be issued.

Deer Damage Claims: Some states have tried paying the farmer for his loss due to deer and other wild game but they found it is very unsatisfactory as some farmers abused this method by planting crops in the midst of heavy deer numbers just to collect money on deer damage claims.

5. Herd Reductions: This has long been recognized as an effective tool in the management of big game. In areas where game populations exceeded the carrying capacity of their range, it becomes necessary to reduce those populations to prevent the deterioration of this range and to prevent the accompanying loss of deer due to malnutrition and disease.

In many parts of California today the increase of deer populations has resulted in such problem areas, and herd reduction has been recommended by men who have studied these areas. Men who are well-versed in wildlife tech-

niques recognize the need for immediate herd reduction in over-populated areas, and perhaps the deer are aware of their over-crowded conditions; but it is another matter to convince the laymen that there are too many deer. The sportsman will reply with the story of how they have hunted very hard the last few years to fill out their deer hunting tags. If these same people had looked closely at the native browse in the area where they had hunted they would have noticed a definite "browse line" which has been long recognized as a danger sign indicating over-browsing. There are a few farmers and sportsmen, however, who can see that in sections of California today something must be done to control excessive numbers of deer. Even after the majority of the people have been convinced that herd reduction is a practical and valuable method to use in the management of our deer herds, there is another and more serious obstacle to surmount before we can actually go ahead with herd reduction in an efficient manner. It is difficult to find a feasible method of herd reduction which will satisfy the farmer, sportsmen and the general public.

In areas where crop damage is heavy due to a large number of deer, deer are sometimes trapped and transplanted to sections of the state where deer are scarce and where they can do no harm to agricultural crops. This method is very costly and has not been satisfactory in view of the high cost involved. Other states have tried it and have

found it unsatisfactory also.

Professional men in the field of Wildlife Management and other related sciences generally agree that the only practical method to reduce a deer herd when it is out of balance with the environment is to have an open season on antlerless deer. This has been recommended to the people of California by the game biologists of the Division of Fish and Game. This recommendation has been met with fierce opposition by well-meaning sportsmen of this state. Many believe it is a crime to kill a doe, and say it would not be any sport at all. They also believe that if female deer were taken each year that soon there would be no deer in California. Minnesota has had an antlerless deer season for a long while and today boasts of large numbers of deer. Other states harvest a certain percentage of their female deer and elk each year with satisfactory results. Other states have tried hard to obtain an open season on female deer. The late Aldo Leopold who was a highly respected authority on game management problems appealed to the sportsmen of Wisconsin for many years to get a season on antlerless deer in over-populated areas of Wisconsin.

People who are not familiar with management principles advance the argument that to reduce the numbers of deer all that has to be done is to extend the deer season on male deer or to raise the bag limit to 3 or more deer instead of 1 and 2 as it is today. These people do not take into

consideration that if this were done it would further increase the buck-doe ratio which is already far out of balance in many parts of the state. The buck-doe ratio in the inter-state deer herd in Modoc County in 1949 was around 1 to 9.1, and in the Glass Mountain herd it was 1 to 6.6. A buck-doe ratio of around 1 to 3 or 4 is considered a more satisfactory condition in a deer herd (Trippensee, 1948) and there are some that feel this is still a little high. With an increasing number of hunters in California, it is necessary that our deer herds be managed at optimum population levels and the annual surplus of deer must be harvested more efficiently. To obtain a maximum harvest of surplus deer in California it will be necessary to take a certain percent of the females each year. The sportsmen of California must be made to understand that by taking does along with the bucks in the hunting season, it will insure them of a more stable herd in the future and will alleviate serious damage in many areas of California today.

The public can take their choice. Either remove female deer by hunting in the fall or force the man who has crops to protect to shoot them in the spring and summer. During the time between 1932 and 1949 there were 4,500 deer killed on deer damage permits and undoubtedly a large number were killed without permits. Of these 4,500 deer, 2,830 of them were females. From 1945 until 1949 2,283 deer were shot while damaging crops, of which 1,510 were females.

More and more deer are shot damaging crops each year, and more will be shot next year and the next, but this has not solved and will not solve the problem.

SUMMARY

The problem of damage by deer in California is of great importance and is a problem of which the people living here should take more cognizance as it is through them that legislation will be enacted to reduce crop damage to the satisfaction of the most people. The writer was astounded by the number of people whom he contacted during the writing of this paper who were entirely ignorant of the fact that crop damage to any extent existed in their own state or even in their own county. Veteran hunters who had spent many hours in the woods and field in pursuit of game were astonished when they learned that in many areas of California today there exist problem areas of the kind mentioned in previous sections. It is difficult to convince most hunters that there are too many deer.

It is the opinion of the writer that the public relations staff of the Division of Fish and Game should be given adequate funds to carry on a more thorough campaign to disseminate the knowledge gathered by game biologists and wildlife research technicians to the general public. Other agencies than the Fish and Game Departments should take more interest in this problem of public education of vital problems of our wildlife. An un-biased educational program sponsored by any group is a great deal to ask for but it is more than desirable.

The average farmer, sportsman or man on the street can not interpret many of the scientific reports that are included in the quarterly magazine published by the Division of Fish and Game, which is about the only educational publication on matters of fish and wildlife affairs in California today. This quarterly publication is written primarily for those interested in the technical aspects of our fish and wildlife resources and has been invaluable in this respect. It serves as a text and reference to students of biology, ichthyology, mammalogy, zoology, ornithology, parasitology, wildlife management, and many other fields of science and agriculture; to men engaged in the profession, to teachers and to others. It should not be discontinued by any means. What is needed is a supplementary publication or an interpretive issue to be written for the laity in short story form. A delegate of the Fifteenth North American Wildlife Conference summed it up quite well with these words: "Writers have not been able to bridge the gap between the scientific mind and the journalistic mind." If this gap could be bridged and a sound educational program could be promoted, the management of our fish and wildlife would be made more efficient, and some of the prejudices of interested groups could be partially eliminated.

To estimate the amount of damage in monetary figures would be quite difficult if not entirely impossible unless

a separate and long term survey were made on this part of the subject. From present figures that are available any estimates of deer damage in dollars and cents would be nothing better than wild guesses. Figures compiled from questionnaires, interviews, etc., can not be analyzed with any reasonable degree of accuracy. However, a very rough estimate would be at least \$150,000 and not more than \$800,000 worth of damage is being done by deer to crops annually in California, which is about 6/100 of one percent of the total annual value of agricultural products in California. This does not mean much to the economy of the state in general, perhaps, but it does mean a great deal to individual farmers who suffer losses of over \$1,000.00 in one season or in one week in some instances. The amount of crop damage by deer to some individual farmers is often large in comparison with the gross income and consequently represents a considerable part of the profit.

Although the deer in California are certainly causing considerable trouble in certain sections, there is a much brighter side to the deer situation which should not be overlooked. According to a survey made by the Fish and Wildlife Service in recent years, each hunter spends approximately \$75.00 on the average to obtain a deer during the hunting season. This includes initial cost of firearms, ammunition, money spent for travel, food, license, deer tags and others. Gordon (1950) found that the average

hunter in California spends \$41.60 for each deer-hunting trip whether it is successful or not. Using the figure of \$75.00 spent in shooting one deer, and the 1947 figures of the deer kill in California of 47,000, it can be seen that approximately \$351,000 was spent by hunters that were successful in getting a deer. Add to this the amount spent by unsuccessful hunters and it is clear that a considerable amount of money is paid to the people of California. Also by applying the value of \$75.00 per deer to the approximate total number of deer in California, which is around 750,000 to 1,000,000, our deer herd has a value to the state of around \$50,000,000 to \$75,000,000 in monetary terms and more if we include the aesthetic value derived from deer, which is valuable indeed.

Every effort must be made to solve this problem of deer damage to crops and to prevent further deterioration of deer ranges. The most practical and efficient method to do this and to harvest the maximum amount of surplus deer is to remove the surplus numbers of female deer along with the surplus numbers of male deer. This should be accomplished by having an open season each year on antlerless (female) deer in sections of the state where surveys show an excess of deer.

CROP DAMAGE BY WATERFOWL IN CALIFORNIA

In the vast breeding grounds of Canada, Alaska, Greenland, and portions of northern United States, millions of waterfowl are produced annually. With the advent of fall, these birds migrate southward along ancestral migratory routes to their wintering grounds. With data obtained from observers and from bird banding returns, these main migration routes have been roughly established and are termed "flyways."

Atlantic Flyway

This route originates in Greenland, northeastern and central Canada, and continues down through the New England States and along the Atlantic Seaboard to Florida, Mexico, and South America.

Mississippi Flyway

This begins in northeastern Alaska and northern Canada and funnels down through the Mississippi Valley to Florida, Louisiana, and other southern states and continues on into Mexico, Central and South America. (Lincoln, 1947)

Central Flyway

This flyway begins in northeastern Alaska and northern Canada and continues on down through the United States from western Minnesota to Idaho in the north and from Louisiana to Arizona in the south. It terminates in Mexico and South America.

Pacific Flyway

It begins in Alaska and northwestern Canada and continues down through the Pacific States from Montana, central Utah, and New Mexico westward to the ocean and along the Pacific Ocean to Mexico and South America.

The total population of waterfowl using these flight paths varies from year to year, but the comparative use of these routes has been roughly determined. Records show that approximately 37% of all migratory waterfowl are within the range of the Pacific Flyway. Figures recently released by the U. S. Fish and Wildlife Service indicate an approximate total population of waterfowl in North America of 125,000,000 to 150,000,000 birds. Multiplying this figure by the percentage figure for the Pacific Flyway, we obtain 45,000,000 to 55,000,000 as the total estimated number of ducks, geese, swans and coots breeding, wintering, and traveling in and through the Pacific Flyway.

California is one of the most important areas of the Pacific Flyway, mainly because for untold centuries vast numbers of waterfowl have depended upon it for feed and rest during the winter months. At one time California was an ideal haven for wintering birds, with its mild winter climate and extensive marsh areas. These marshes occupied the larger part of the Great Central Valley and extended from Chico to Bakersfield, and they provided large quantities of natural feed for these winter residents.

As California was developed, these marshes were drained to provide more land for agriculture and other interests. Waters were impounded; irrigation and flood control projects soon changed the face of many areas of the state, until today only a very small proportion of the original waterfowl habitat remains. According to Horn (1949) the remaining good waterfowl habitats have dwindled down to these areas:

1. A small unit along Butte Creek in the Sacramento Valley. This seems to be the best area.
2. The Colusa trough running adjacent to the Sacramento Waterfowl Refuge, and along what is locally known as the 20-47 drainage canal.
3. The "grasslands" of the central San Joaquin Valley running down through Merced, Los Banos and terminating at Dos Palos.
4. The confluence of the Sacramento and San Joaquin Rivers which is Suisun Bay.

At the present time, 1950, there are virtually no suitable waterfowl areas between Mendota in Fresno County and the Salton Sea in the Imperial Valley, which is in the extreme southern end of the state. This latter area is not part of the original waterfowl habitat in California as it was formed by overflow waters of the Colorado River only during the last half century. Two of the original areas mentioned above will be further reduced by irrigation and flood

control projects. These are the Butte Sink and the grassy marsh areas of the San Joaquin Valley.

As the natural feeding and resting areas for waterfowl decreased, the amount of land made available for farming increased. The millions of waterfowl coming south each year were forced to substitute crops grown by the farmer for the natural pond foods, until today they seem to prefer these cultivated crops over their native food. Consequently, crop damage has steadily increased in California with the exception, perhaps, of the period around 1935 and 1936 when waterfowl populations were at their lowest. Crop damage became so heavy by 1942 that the California Farm Bureau made a special survey of the situation to determine what might be done to reduce losses incurred by the farmers. In 1943 the Agricultural Adjustment Administration, California Division of Fish and Game, and the U. S. Fish and Wildlife Service joined with the Farm Bureau and made a more complete survey of crop damage at that time. In 1944 the Imperial County Farm Bureau Game Depredation Committee was organized to protect the interests of farmers of that area who suffered staggering losses from lettuce, alfalfa, rice, wheat, and barley in the winter of 1943-1944. This committee is very active at the present (1950).

A similar committee was formed in the northern part of the state consisting of farmers, sportsmen, and officials of the California Division of Fish and Game and the Fish and

Wildlife Service.

A few years ago the U. S. Fish and Wildlife Service established an office in Berkeley, California primarily to deal with the problem of crop depredation by migratory birds in the western United States. More recently the California Conservation Board with Seth Gordon as consultant set up a three-point program for dealing with this problem. This three-point program sums up fairly well what all of the above-named committees and agencies hope to achieve:

1. The needs that must be met to take care of waterfowl as a natural resource to perpetuate and utilize.
2. To provide means to feed waterfowl and minimize crop depredations.
3. To make available to the common hunter a place to get a full day's shooting.

At the present time these organizations and agencies are working together on this problem. They are trying to reduce crop damages incurred by farmers and to eliminate the threat to our waterfowl populations which was brought about by the decrease of natural feeding and resting areas.

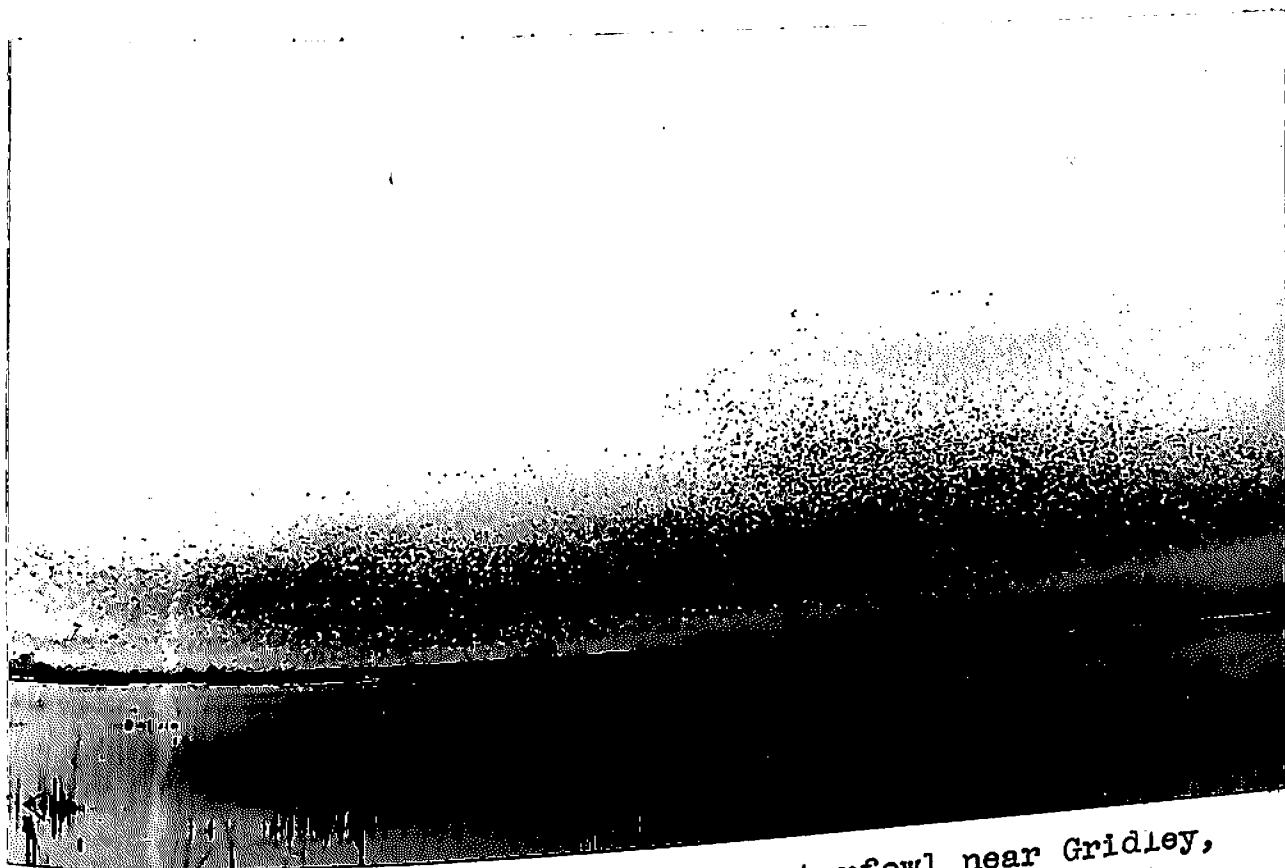
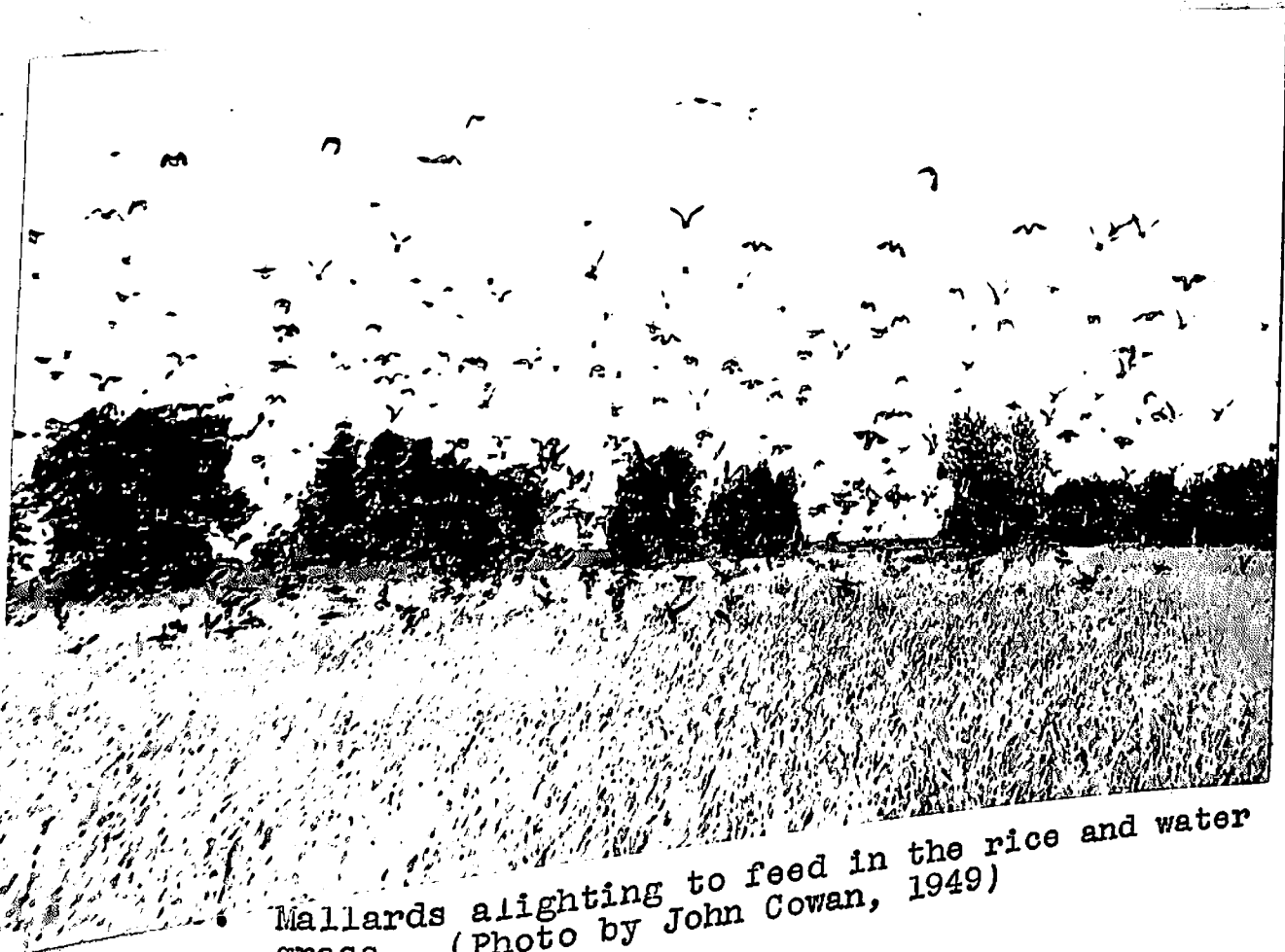


Figure 8. Large concentration of waterfowl near Gridley, California. These birds must eat somewhere and often it is in a commercial rice or grain field. (Photo by John Cowan, 1949)

THE NATURE OF DAMAGE BY WATERFOWL

In California, farmers experience crop losses from a variety of waterfowl species. Oddly enough, each species seems to have its own peculiar way of causing damage.

Mallards, Anas platyrhynchos platyrhynchos (Linnaeus) and Pintails, Anas acuta tzitzihua (Vieillot) are both pond, or dabbling, ducks. Crops affected by these ducks are chiefly rice, wheat, and barley. Damage to these crops is due to the actual consumption of the grain or rice and by trampling of the crop, making it difficult and sometimes impossible to harvest. Frequent flooding is necessary to grow rice. As the rice reaches maturity, the water is taken off and the land is left to dry so the rice may be harvested. Usually there is a low spot in the rice field where water is left standing. Ducks hatched in this area as well as those in migration find this small pond with an abundance of food very much to their liking and begin to eat the rice in this area and to trample down the stalks, soon making a small opening in the rice which enables birds passing overhead, in the morning and evening, to see the water. These birds come down and join the ones already there, and the area of damage is soon enlarged as the ducks feed out onto the dry ground of the rice field. If these birds are allowed to remain; and if more birds are allowed to join them, hundreds of acres of rice may be damaged in a very



Mallards alighting to feed in the rice and water grass. (Photo by John Cowan, 1949)

short while. Rice damage by ducks usually occurs, or at least begins, and follows this general pattern. (Baker, 1944, p. 47)

Damage to grain and rice occurs mainly from the time the large migratory flocks come into California in August until the crops are harvested in September and October. If weather prevents the harvesting of these crops, the season of damage is extended and losses incurred are unbelievably great. This is true especially to individual growers, because ducks for some reason, as yet unknown, will concentrate their attacks on one field and leave the field lying adjacent to it entirely alone.

Widgeon or baldpate, Mareca americana (Linnaeus), are also a member of the pond or dabbling duck group, but unlike the mallard or pintail, they prefer the grasses and the green cultivated crops to the cereal crops. In California, widgeon feed chiefly on young fall-planted barley, alfalfa, clover, pasture grasses, lettuce and a variety of native grasses. Of these, damage to lettuce is the most serious. A large flock of widgeon can completely destroy a field of lettuce in a few nights. See Figures 10 and 11. Damage to lettuce is the result of the ducks eating the entire head in some cases and rendering others un-marketable. Widgeon also damage alfalfa and clover to a considerable extent by eating the plant and by puddling the ground with their feet when these crops are flooded by irrigation or



Figure 10. Mr. Charles Nice, left, Secretary Brawley Chamber of Commerce, holds remains of a head of lettuce, while William Batley, Manager, Western Fruit Growers holds uneaten head. This 300 acre field of lettuce was destroyed in ten nights by widgeon. Crop was almost ready for shipment and had an investment of \$100.00 per acre. Photo taken February 10, 1943. (Courtesy of Imperial County Game Depredations Committee)



Figure 11. View of entire lettuce field where the above damage occurred. Photo taken near the town of Brawley, California, February 10, 1943. (Courtesy of Imperial County Game Depredations Committee)

rain, which makes it as hard as concrete when the water is removed and this causes the plants to die in many instances. In the Imperial Valley, pintail and widgeon are the chief offenders on these irrigated pasture crops with other species also helping out to a minor extent. Widgeon consume enormous quantities of young grain in the winter months. Grain that has been planted in the fall begins to break through during the winter months and provides a large quantity of green feed to these wintering birds. Damage does not occur to the grain if the soil is dry. The birds eating the young shoots at this time only cause them to "stool" out, which means branching, and aids in the production. However, when large numbers of waterfowl feed in a grain field when it is well-soaked by rain, damage is often very heavy. At this time the young shoots may be entirely pulled out of the ground and eaten, or the plants may be trampled or puddled so severely they will eventually die. See Figure 14. Grain damaged in this manner must be re-planted in many instances, or suffer a reduction in the average yield per acre.

Damage to pasture grasses consists mainly of the loss of feed for livestock. In addition to eating the grass, widgeon and geese sometimes spoil a pasture for grazing cattle by "souring" these areas with their waste products. There is no definite yard stick that can be used to measure the amount of pasture damage caused by waterfowl except to

state it in terms of grazing units or animals' months of feed lost. To further estimate the amount of damage thus inflicted the writer conducted an experiment--the results of which are contained herein.

Experiment: The area selected for the experiment lies between Farmington and Escalon in San Joaquin County, California, and on the property of Mr. H. Goodrich. For many years Mr. Goodrich has lost the use of pasture lands due to large concentrations of widgeon and a small number of other waterfowl species. At this time, February, the pasture was well dotted with small water-holes which provided an excellent resting place for the birds, as well as a good feeding area. This pasture was measured to be 1400 yards long and 610 yards wide and contained 846,000 square yards. The experiment was conducted to determine the number of duck-hours spent on this pasture and approximately how much food was consumed during that time. The field was measured off in smaller units of 100 yards square. See Graph 9. At the areas marked x in the figure, smaller plots of one square yard were measured. The individual pellet-groups or droppings were counted in each of these yard square plots. See Figure 13. In all, ninety such plots were counted. The average of these was recorded as fifteen pellet-groups per square yard. This figure was then applied to the entire area and resulted in a total figure of 1,273,000 waterfowl droppings or pellet-groups.

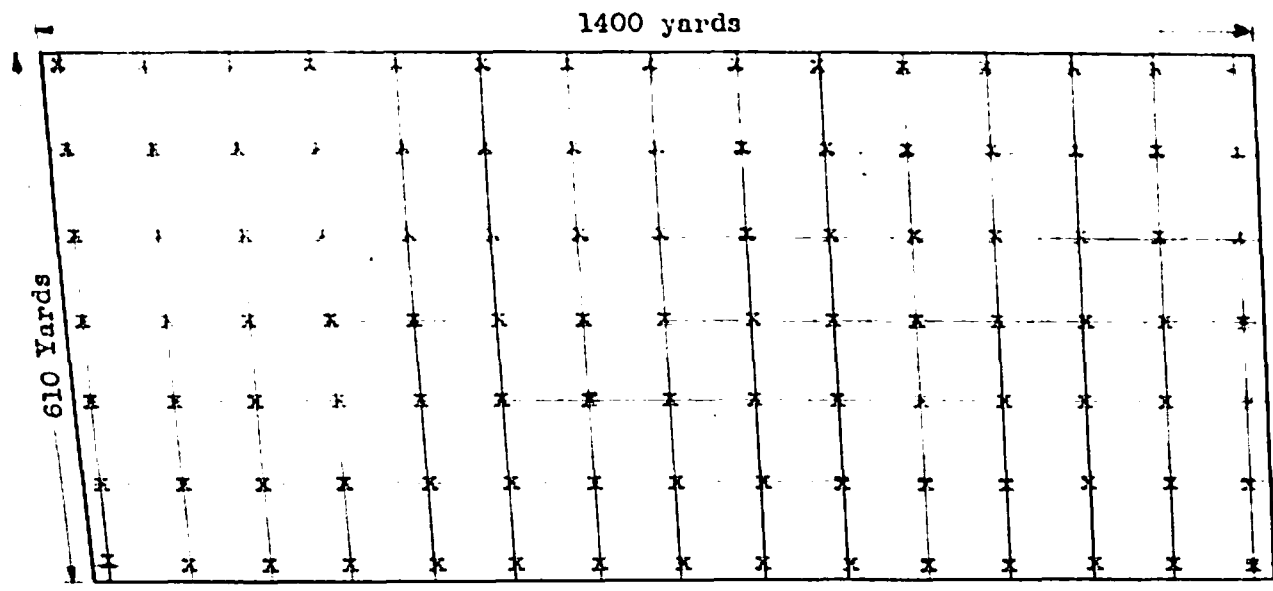


FIGURE 12

To determine how many duck-hours this figure represented, four widgeon, one mallard, and one sprig or pintail were trapped and penned for observation. When the birds became more accustomed to their new surroundings, accurate records were kept of food consumption and data was recorded on the number of droppings per hour. The four widgeon were fed weighed amounts of grass and clover and a little mixed grain. The mallard and pintail were fed weighed amounts of grain with a small amount of clover. All birds had a large puddle of fresh water and plenty of grit at hand. Accurate records were kept for two weeks. At the end of this period all birds were liberated with a slight gain in weight.

Results of Experiment:

- (1) Widgeon ate approximately four ounces of green feed each day if it was available, and pintail and mallard ate approximately seven ounces of grain each day per duck.
- (2) Based on this experiment the average number of



$\frac{1}{2}$ inch = 100 yards

x represents 1 sq. yard

GRAPH 9
 Experimental plot in San Joaquin County to
 determine pasture damage by waterfowl.

droppings per hour for all six ducks was 30 or 5 per hour per duck. Other experiments along this line should be performed. Using these figures on a twelve hour basis it is concluded that each duck accounts for 60 droppings each day.

(3) The number of duck-days that waterfowl spent on this experimental area was $\frac{1,275,000}{60}$ or 21,300 days or 250,000 hours, assuming that waterfowl droppings would last for one week in good weather.

(4) Multiplying the number of duck-days by the amount of feed consumed each duck-day gives a total amount of feed eaten by waterfowl (mainly widgeon) of 5,340 pounds which represents approximately \$70.00 if alfalfa hay is used as a comparison.

(5) The birds had been on this pasture mainly during the past week before the experiment was started which indicated a population of around $\frac{21,300}{7}$ or 3,000 birds using this area for feeding. According to the owner, these birds depend on this pasture for about six weeks out of the year and sometimes longer. This would mean a loss in feed of around \$420.00 for the year.

Damage by Geese: Geese, principally the lesser snow, Chen hyperborea hyperborea (Pallas), the white-fronted or speckle-belly, Anser albifrons albifrons (Scopoli), the cackling goose, Branta canadensis minima Ridgway, and the canadian honker, Branta canadensis

canadensis (Linnaeus) do considerable damage to pasture lands, irrigated pasture crops and young grain. The damage is done in the manner described for widgeon. See Figures 13 and 14. Geese feed chiefly in the morning from 7-10 and in the afternoon from 3:00 until after dark, and sometimes feed all night. They usually return to their resting areas at night and return to the fields the next morning. When the feeding and resting areas are together, waterfowl will feed continuously when they are not sleeping.

Coots, or mudhens, Fulica americana americana Gmelin, belong to a different order of waterfowl than do ducks and geese but cause considerable damage each year to irrigated pasture crops, vegetable crops, young grain and pasture lands. These birds concentrate on sloughs, ponds, drain ditches, and creeks adjacent to rangeland, permanent pasture, alfalfa, clover, and grain and feed off these crops from the time of sprouting in the fall until the latter part of April, and in some areas this damage continues throughout the year. In 1948, coots or mudhens destroyed a 30-acre field of young peas in one week on the ranch of Atkins and Kroll in San Joaquin County. Sugar beets and other vegetables are also included on the damage list of these birds.



Figure 13. Barley field eaten by widgeon and geese. Picture shows normal stand of barley along the fence and damaged barley towards center of field in foreground. Much of barley has been pulled out and eaten. (Photo taken by author near Farmington, California February 8, 1950)



Figure 14. Barley puddled by geese. This barley was pulled out and eaten or trampled so badly it will never recover. When this puddled area dries, it will be as hard as concrete. (Photo taken by author on Staten Island, San Joaquin County, California February 21, 1950)



Figure 15. Fall-planted grain in Colusa County, California, adjacent to a small pond which harbored a few hundred widgaon and mudhens or coots. These birds had eaten off a considerable area away from the pond. Comb was placed in a normal stand of young grain. (Photo by author, January 28, 1950)



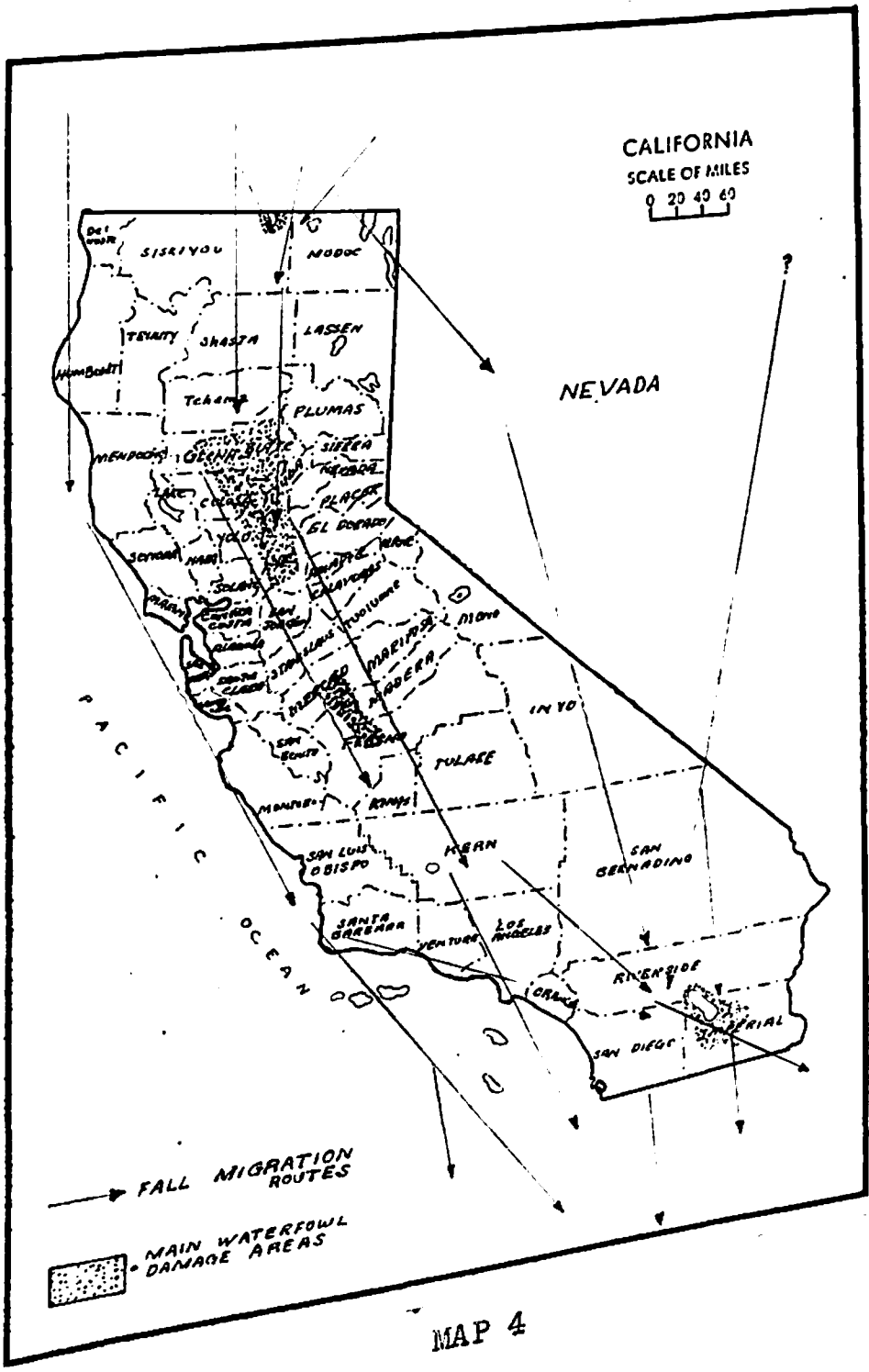
Figure 16. This is the same field of young grain as above, only closer to the pond. This grain will now "stool" or branch out unless it is continually eaten off. Just the tops have been eaten. When ground is wet, grain is easily pulled out and destroyed. (Photo by author, January 28, 1950)

THE EXTENT OF DAMAGE

Unlike the distribution of crop damage by deer, damage by waterfowl is concentrated in four general areas of California. See Map 4.

1. Tule Lake Area - This area consists of the old Tule Lake bed and the Lower Klamath Lake region, part of which is in Oregon. Tule Lake once covered over 80,000 acres and was a large, shallow body of water with many miles of tule bordered shoreline, and food producing marshes. Today most of this area has been reclaimed and dedicated to agricultural use. It is mainly on this reclaimed land that crop damage is occurring. Barley is damaged the most and usually from August to October. According to Sargent (1949) ducks begin to funnel into this area around the first of August, reaching their peak concentration of around four and one-half million by the latter part of October. Geese, numbering three-fourths of a million are found in this area about the last part of October and first part of November. Widgeon and pintail are the worst offenders on grain. In 1947 the operator of a very large ranch lost \$80,000.00 due to waterfowl feeding on mature grain. (McKinney, J. O., Agricultural Commissioner Siskiyou County, Letter February 17, 1950)

II. Sacramento Valley - Most of the damage occurs along Butte Creek from Willows to Woodland and from Maxwell to the delta region of the Sacramento Valley. Rice and



MAP 4

barley receive the most serious damage from August until the crops are harvested and in the winter when the young barley is breaking through the ground. Mallards and pintails begin to arrive in early August and waterfowl, (all species), reach a peak of around six to eight million in November and December. At least one million of these are geese. In the next few years, Ladino clover, alfalfa and other pasture crops will probably be damaged more seriously in this area as many farmers are changing over from grain and cereal crops to pasture crops. One year the total damage to rice crops in the Sacramento Valley was well over \$700,000.00

(Horn, 1949)

III. San Joaquin Valley - Most of the damage occurs between Dos Palos southeast to Tranquility and along the Santa Fe Grade. There are approximately 20,000 acres of rice in which most of the damage occurs. There is, however, a great deal of damage to pasture crops, young barley, and pasture lands by coots or mudhens and geese in the delta area, in the Escalon area and in the Merced area. Damage here is approximately \$200,000 annually depending upon the weather. (Danison, E. A., Agricultural Commissioner of Merced County, letter April 18, 1950)

IV. Imperial Valley - This section of California is unique in this problem because the reasons underlying crop damage are practically in reverse of what we have said about the rest of the state. This valley was once a barren and

parched desert until men brought water into it almost 50 years ago. Flood waters from the Colorado River formed what is now the Salton Sea. Before this body of water was formed, migratory waterfowl probably traveled right through this region without stopping. The Salton Sea now provides a fair resting place for thousands of waterfowl each year. After the completion of Boulder Dam, enormous quantities of water were made available to this valley and today it boasts of over 3,000 miles of irrigation canals and drain ditches. The Imperial Valley now produces over \$120,000,000 worth of agricultural crops each year. Vegetables are the most important crops grown, with lettuce at the head of the list with a gross value of \$17,000,000 annually. Below is part of a survey made by Horn (1949, p. 577):

This valley harbors a population of widgeon fluctuating from 100,000 to 400,000 birds. These feed principally on green feed; taking lettuce, alfalfa, and growing barley. In addition, pintail occur in good numbers with mallard, redheads, scaup and ruddies in smaller numbers.

Damage by geese has been increasing in the area during the past few years also. An estimated survey of the crop damage for those who reported their losses during the winter of 1943-1944 in Imperial Valley was in excess of \$500,000 which is a very conservative estimate indeed. (Loveland, B., letter of February 16, 1950) One grower of lettuce lost \$30,000 in 10 nights, another lost \$60,000 in one week due to widgeon. The former loss is pictured in Figure 11.

There are many counties in California that do not have any crop damage at all by waterfowl. I have omitted these and include only those that have reported crop damage to any extent.

Siskiyou County: Coots take a toll each spring from young alfalfa and sprouting grain. Pintails, mallards, and widgeon do extensive damage to barley each fall. Estimated damage by all species of waterfowl is \$80,000 each year. (McKinney, J. C., Agricultural Commissioner, letter of February 17, 1950)

Modoc County: Ducks, Geese and coots damage grain, pasture crops, and young barley. No damage estimated. (White, L., Agricultural Commissioner, letter April 3, 1950)

Lassen County: Geese damage cereal crops by eating mature grain in August. Estimated damage \$3,000 annually, in 1949. (Fix, E. E., Agricultural Commissioner, letter April 3, 1950)

Shasta County: Geese feed in grain fields and on hay crops all night and entirely eat 10 acres of grain in one night. Estimated damage is 10 to 15 thousand dollars annually. (Stroup, B. F., Agricultural Commissioner, letter February 17, 1950)

Tehama County: Ducks and Geese damage seedling barley, but not enough to estimate accurately. (Ansell, S. T., Agricultural Commissioner, letter April 1, 1950)

Plumas and Sierra Counties: Waterfowl damage occurs

on grain crops, mostly barley. One third of damage is in Indian Valley due to mallards. Canadian honkers damage alfalfa in Sierra Valley. (Young, A., Farm Advisor, letter February 14, 1950)

Glenn County: Widgeon damage ladino clover to the extent of approximately \$8,000 annually. Pintail and mallards damage rice and grain crops for a total of \$40,000 or 1% of the crop. (Lundeen, H. L., Agricultural Inspector, letter February 24, 1950)

Sutter County: Severe damage by ducks to rice and grain. Widgeon and geese do some damage to pasture crops and young barley. Mudhens present an annual problem also. Damage can not be estimated at this time. (Urbahns, T. O., Agricultural Commissioner, letter April 4, 1950)

Butte County: Damage here follows the general pattern outlined for Sutter County, but is more severe. Annual damage at one time was well over \$90,000. (Kingwell, 1950)

Colusa County: There is more rice grown in this county than any other in the state. Consequently, damage by ducks has been very great. In 1943-1944 growers lost an estimated \$200,000 in cereal crops from marauding pintail and mallards. (Kingwell, H. M., Agricultural Commissioner, Interview February 6, 1950) Damage also occurs to ladino clover, alfalfa, young barley and pasture land by widgeon, geese and mudhens.

Yuba County: Some damage occurs to barley in the winter due to mudhens and geese, and crops are damaged by ducks. Estimation of damage not reported.

Yolo County: Annual damage to cereal crops by ducks; and damage to young grain and permanent pasture by geese and mudhens.

Sacramento County: Geese and mudhens injure grain in the Sacramento Delta. Damage occurs to rice fields in years of early rains. (Morrison, A. E., Agricultural Commissioner, letter February 20, 1950)

Solano County: None other than damage to permanent pasture by mudhens in the spring of each year. This amounts to approximately \$4,000 annually. (Pohl, G. A., Agricultural Commissioner, letter March 31, 1950)

San Joaquin County: Since very little rice is grown here, damage of that type is very little but not entirely absent. Mudhens damage clover and permanent pasture in the Escalon and Delta areas. Ducks, geese and mudhens do severe damage to young grain fields, and the fields must be re-planted in some instances. A conservative estimate of \$15,000 worth of damage by all species of waterfowl is given for this county by the Agricultural Commissioner. It is the opinion of the writer that mudhens do considerably more damage than this alone. Asparagus flooding invites the birds into this area.

Contra Costa County: Mudhens damage grain by

trampling; and geese damage young barley and wheat in the Jersey, Palm, Holland and Webb tracts to the extent of about \$1,000 annually. (Stevens, N. E., Agricultural Commissioner, letter April 30, 1950)

Stanislaus County: Ducks damage rice each year, but main damage problem is caused by mudhens in grain fields. Annual damage is over \$1,000. (Schrock, M. M., Agricultural Commissioner, letter April 17, 1950)

Merced County: A staggering amount of damage is reported as being inflicted to rangelands, permanent pasture, alfalfa, and grain by mudhens. Rice damage is much reduced in this county due to earlier harvesting and drying of rice by dehydrating. Geese do some damage to grain and pasture. Total amount of damage is estimated to be over \$250,000 annually. (Danison, E. A., Agricultural Commissioner, letter April 18, 1950) Note: It is the opinion of the writer that many of the above counties have under-estimated their crop losses and that Merced County has over-estimated theirs.

Los Angeles County: Occasionally mudhens become abundant on small ponds adjacent to alfalfa fields and cause some damage not to exceed a few hundred dollars. (Becker, E. M., Agricultural Commissioner, letter February 23, 1950)

Orange County: During wet years when considerable water stands in low areas adjoining crop lands, damage occurs from mudhens and ducks, particularly on sugar beets

and other vegetable crops. No estimation of damage is reported. (Dudley, E. A., Agricultural Commissioner, letter March 13, 1950)

Imperial County: This county was covered previously under crop damage in the Imperial Valley.

TREND OF DAMAGE BY WATERFOWL

No accurate records are available to determine the exact trend of crop damage by waterfowl in California; but damage complaints have steadily increased with expanding agricultural practices. The growing of rice on a large scale began around 1918. (Neale, 1918) Since then, more land has been devoted to rice principally in the Sacramento and San Joaquin Valleys until today rice is grown on more than 275,000 acres. Rice fields provide a better habitat for waterfowl than the original marshland. According to food-habit studies made on waterfowl, rice is the most important item in a duck's diet when it is available. Mallards and pintail, especially, will leave barley, wheat, corn, and their native pond weeds virtually untouched when rice is in the area. This preference for rice, together with the fact that most of the rice is grown in areas that were once the best of the original marsh land, accounts for the increasing losses sustained by rice growers. A similar combination of these factors accounts for the increasing damage to vegetable and pasture crops by widgeon in the Imperial Valley with the exception of the fact that here an entirely new feeding area has been established where barren wastelands existed before.

Colusa County, which is the largest producer of rice in the state, shows a damage trend which may be applied to

most of the rice areas. Damage to rice steadily increased from 1920-1933. From 1933-1937 there was a noticeable decrease in damage due to the fact that the population of waterfowl during these years was at a dangerously low level. Damage continued in an upward direction from 1937 until 1942. In 1942 and 1943 crop damage in this county increased at a tremendous rate due to these reasons: (1) Waterfowl populations were increasing very rapidly at this time. (2) Because of World War II, there was a shortage of ammunition both for herding the birds and for sportsmen's use and a sharp decrease in the numbers of hunters. (3) Wet weather and labor shortages increased the time of harvesting and enabled the birds to damage more rice. (4) Improperly prepared rice fields made ponds a starting point for ducks. These improperly prepared fields were more numerous during the war. (Interview with Tyrell Sartain and H. Kingwell of Colusa County, January 18, 1950)

In 1944 a good crop of grain grown on Federal wildlife refuges reduced the amount of damage in Colusa County to a very low level. It was in this year that the ducks came into California a little later than usual which helped to reduce the damage. From 1944-1948 damage again increased in Colusa County due to a late commercial rice crop and a poor crop on the Sutter waterfowl management area. A survey made by the California Farm Bureau Federation in 1942 showed a loss of rice of 200,500 bags of rice

which was valued at over \$600,000. In 1943 a more thorough survey was made by State and Federal agencies which revealed a loss of 258,804 bags of rice which was valued at \$905,000. (Horn, 1949) In the Imperial Valley a survey was made during the winter of 1943-1944 which showed a loss mainly to lettuce and irrigated pasture of well over \$500,000. (Loveland, 1950) Measures taken to prevent the repetition of such enormous losses have resulted in a general decrease in damage over the state during the last few years.

METHODS OF CONTROL

From the time crop damage by waterfowl began until the present time, a wide variety of methods have been used to prevent crop depredation. These have met with varying degrees of success. The earlier methods of protection consisted of killing the birds that were doing the damage. Market hunting, which was legal at that time, was encouraged by property owners. These market hunters killed hundreds of ducks and geese in a single day. Besides the birds that they obtained for the market, they were sometimes paid by the farmer, who wanted the birds destroyed or driven away.

Frightening Devices:

1. Shotguns and Small-bore Rifles are being used but are effective only on small areas. Ammunition is very expensive for the extensive use of shot guns and the rifles are rather dangerous in open country.

2. Very signals are really a type of roman candle which cause the birds to lift from a field. It is most effective if fired from an airplane. (Lostetter, 1949, p. 109)

3. Ground Mortar Bomb - The fuse of this bomb is lit and the bomb is dropped into a mortar. It explodes 300 feet in the air and is fairly effective in frightening birds at night as there is a loud explosion and bright flash of light.

4. Various Flash and Sound Devices - These include many types of fireworks, sirens, bonfires, hand grenades, carbide exploders and others, and are only slightly effective on small areas of land; and only until the birds become accustomed to them.

5. Rifle Grenade - This is a large (14 inch) missile similar to an airplane bomb and is fired from a converted 30-06 army rifle, called a rifle grenade launcher. The flare explodes in the air and consists of two types, the parachute flare that lasts for ten seconds and a star cluster that lasts for 4-5 seconds. This grenade is very effective in frightening ducks and geese out of quite a large area. One man can easily cover 800 acres. It is effective in the daytime as well as night. This writer has witnessed very effective demonstrations of this type of frightening device on Staten Island where geese were driven entirely out of the area during the day by a single grenade. These grenades and rifles may be obtained by ranchers free of charge from the U. S. Fish and Wildlife Service in Berkeley, California or through a local game law-enforcement officer.

6. Revolving Lights - This is one of the latest methods that is being employed by the Fish and Wildlife Service in their aid to the grower. The lights are of 100,000 to 380,000 candle power and revolve counter-clockwise at a rate of one revolution per minute or

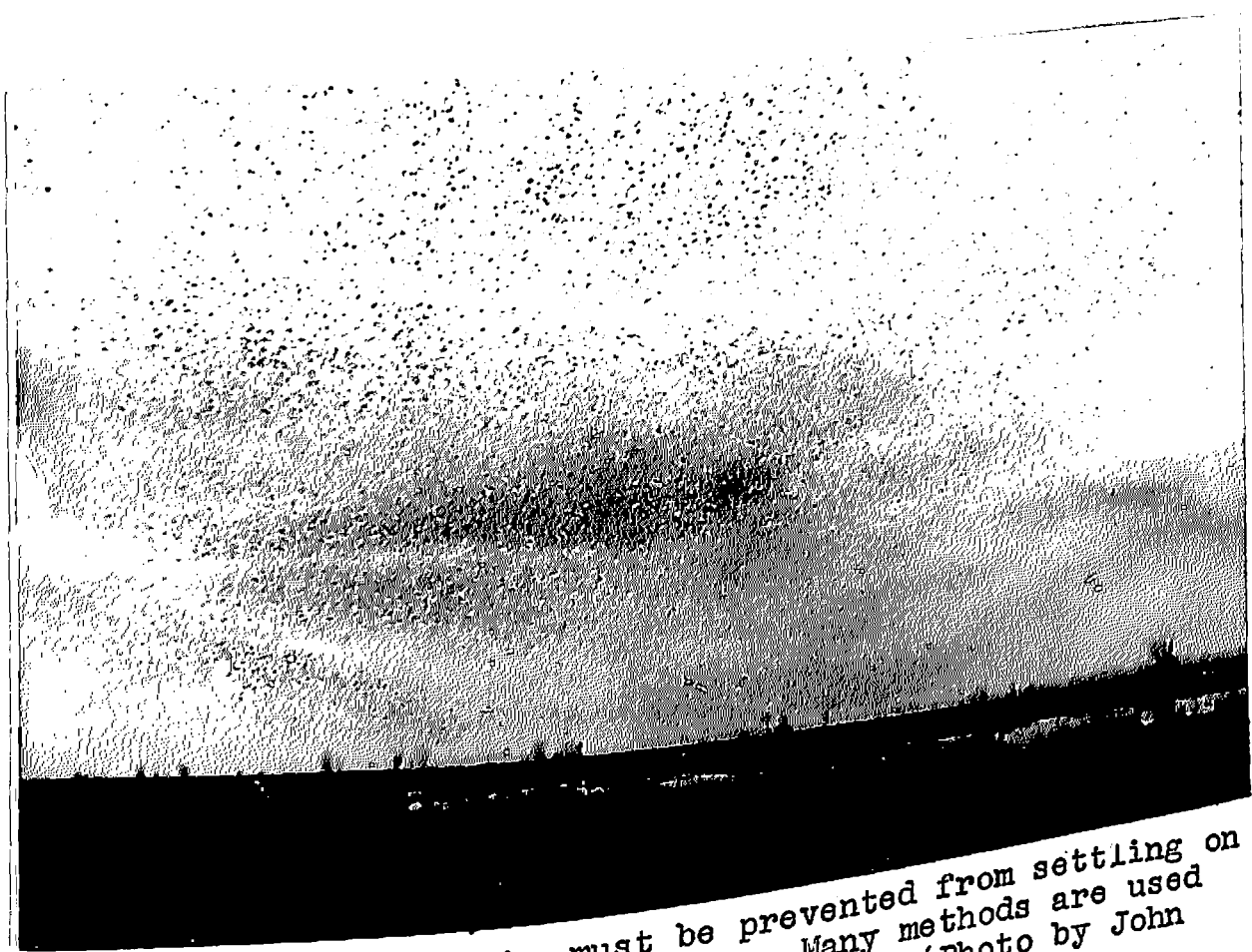


Figure 17. These ducks must be prevented from settling on commercial croplands. Many methods are used to frighten the birds away. (Photo by John Cowan, 1949)

regulated to cover 1/4 mile a minute. One of these lights will successfully cover 640 acres or more if no blind spots or shadows occur as a result of ditch banks, trees, etc. The cost of building one of these larger lights is approximately \$200 to \$350.00, including the turntable. Smaller lights can be purchased commercially for \$50.00. The cost of operation is less than \$1.00 a night. There are 62 such lights in operation in the Imperial Valley this year, (Loveland, B., letter of February, 1950) and quite a number in the Sacramento and San Joaquin Valley. Although these lights may be left unattended most of the time, there are some farmers who have suffered damage from waterfowl when their single unit light burned out during the night, leaving their crops un-protected. Some have partially solved this by using a horizontal arrangement of four or more lights. (Anderson, 1944) The advantage of this light is obvious. If one light burns out during the night its usefulness is not lost. These lights are usually of a smaller size and do not cover as large an area as do the single search-light type of lamp. Whether or not the birds will become accustomed to this form of protection is at present only speculation. The farmers that are using these lights, however, are convinced of their value as a method of damage control.

Herding Permits: When growers hire men to intentionally "herd" migratory birds from commercial crops,

a herding permit must be obtained from the U. S. Fish and Wildlife Service. Herding is very expensive for the farmer and is included in annual estimations of monetary figures of crop damage. Herding is done in several ways: (1) By men on the ground that walk through the fields frightening the birds by shooting at them with rifles, shotguns, or by using any of the fore-mentioned "duck bombs" and flares. (2) Many farmers employ mounted riders who herd the birds out of the crop area in a similar fashion as do the men on foot. (3) The most effective method of herding is done by airplanes. Waterfowl are deathly afraid of a low-flying plane and can be rather easily driven out of a rice field or off any crop. When birds become stubborn and refuse to lift from a field, commercial herders drop bombs and flares on them. This causes them to lift off the field and the plane can get under them and take them to other areas. Many types of crops are protected by herding in this way. One plane can adequately protect 10,000 acres very easily. Thousands of dollars are spent annually for herding waterfowl from crops by these methods.

Killing Permits: In extreme cases of crop damage, permits have been issued to farmers allowing them to shoot offending migratory birds. The birds that were shot in this manner were turned over to charitable institutions. Because of abuses encountered by holders of these permits, they are almost impossible to obtain for killing ducks and geese, but

may be obtained more easily for coots and wild pigeons. Shooting ducks and geese will not solve the problem for any length of time. The enraged farmer may get a little satisfaction by releasing his emotions in this way. But he actually works against his interests. He usually wounds more birds than he kills, and the wounded birds set out there day and night calling other birds down into the fields, in the form of a "live decoy."

Management Areas: The herding of these birds on the ground and by airplanes and the use of frightening devices were effective in protecting crops in certain areas. But it only caused the birds to move on to crops that were not being protected by these methods. It soon became evident that a place must be provided for the birds to go for food and rest after they had been driven from commercial crops. State and Federal waterfowl refuges that had been established in the early phase of the depredation problem did not reduce crop damage to any extent as they provided a place to rest but not an adequate place to eat, and the birds had to "go out to eat."

Hand feeding of threshed barley and wheat was begun to hold the birds on the refuge for a longer period of time and allowed the farmers a longer period to harvest their crops. This method is not too satisfactory as most of the grain that was fed in this manner was grown considerable distances from the refuges and management areas. Most of

the grain was grown in the Tule Lake region and shipped to all sections of California and to other western states for hand feeding. This helped to reduce the damage caused by pintail, mallard, teal and other grain-eating birds but the widgeon and geese were another problem.

To further alleviate the problem of depredation, parts of these bird sanctuaries were farmed in a similar manner as the surrounding areas were farmed. Crops such as rice, barley, alfalfa, watergrass, and other palatable duck foods were grown on State and Federal refuges, flooded at the time of depredation and provided ideal feeding and resting places for millions of waterfowl. With areas such as this, it was much easier to frighten and herd the birds away from crops.

At the present time these management areas are not large enough, or not numerous enough to produce the amount of feed necessary in keeping birds from the crops during the entire critical period. The critical period for rice and maturing grain is from the time the birds enter the area until the harvest has proceeded far enough to provide ample stubble areas where the birds may feed in peace. According to Horn, (1949) this is from the first part of August until the latter part of October, depending upon the weather. For example, there are more than one million grain-eating birds in the major rice-growing area of the state during this critical period of approximately 65 days. Using these most

conservative estimates would mean that 65 million duck-days are involved during this time. If we use the results of the experiment previously mentioned, we find that sprig and mallards eat 7 oz. of grain, and, presumably rice, each day. Thus, 7 times 65 million is 450,500,000 ounces or 28,400,000 pounds are required to feed 1,000,000 birds during the critical period. The average yield of rice land in that area is 3,500 pounds per acre. Thus, to raise the required amount of 28,400,000 pounds would take approximately 81,000 acres entirely devoted to this function. Actually, only a small fraction of this area has been devoted entirely to the growing of crops, and has at times served adequately in protecting the surrounding areas. The future program calls for acquisition of more land and enlarging management areas and refuges already present and to establish new areas.

This management plan is being accomplished by the coordination and cooperation of State and Federal agencies, and each is doing its part toward the financing of this project. Actually, the money comes from three main sources:

- (1) The Pittman-Robertson Act, which is a Federal aid in wildlife restoration projects, supplies California with 75% of the funds required for buying and maintaining waterfowl sanctuaries which can not be used for hunting. This money is derived from the tax on sporting goods and ammunition. (Wildlife Leaflet #342)

- (2) In 1947 the Wildlife Conservation Board was

established in California by the state legislature. This board was also provided with part of the para-mutual fund to be used for capital investments in all forms of expanded wildlife restoration projects, and waterfowl management areas are of course included under this heading. Nine million dollars is available for all projects.

(3) The Lea Act, enacted by Congress in 1948 in response to the pressure of agriculture interest suffering from crop damage in California. This act authorizes appropriations totaling \$750,000 for Federal purchase of lands for waterfowl management areas which will be open for public shooting, and this hunting will be administered by the California Division of Fish and Game. The efficiency of this act was aided by the passage of the "Swing Bill" by the California State Legislature which exempted Lea Act lands from taxation. (Loveland, 1950)

The following areas are or will become part of the waterfowl management plan to reduce crop depredation and to provide more hunting areas for the general public.

Tule Lake group of refuges: This includes Tule Lake National Wildlife Refuge of 37,337 acres which is being partially leased to commercial barley growers and part is being planted by the U. S. Wildlife Service for waterfowl feed in a buffer strip around the open water areas. Plans for the future call for planting of the grain in blocks instead of in a small area around the water. This buffer

strip provides good protection in the spring from ducklings but poor protection in the fall, as the ducks can not tell where the government barley ends and the commercial grower's barley begins. This project also includes part of Lower Klamath National Wildlife Refuge and Clear Lake National Wildlife Refuge containing 25,300 acres.

According to the recent report of the Wildlife Conservation Board, the following areas are being considered for expansion and development.

Sacramento Valley:

1. The Sacramento National Wildlife Refuge known as the "Spaulding Ranch," 11,000 acres. This is an inviolate refuge, purchased in 1931 and developed with Norbeck-Andresen Act appropriations. All lands capable of producing waterfowl food crops will be utilized.
2. The Gray Lodge Refuge operated by the State is now 3,000 acres and will be increased to 6,500 acres. All lands are to be developed for maximum production of waterfowl food crops. The entire area will be operated as a management unit, with regulated hunting in season. See Figures 18, 19 and 20.
3. The Colusa Management area known as the "O'Hair Ranch," which consists of 2,400 acres, will be enlarged to 5,000 acres with management the same as Gray Lodge. This is Federally owned.
4. Sutter Management area also owned by the Federal

government, is located in the Sutter by-pass and consists of 1,300 acres to be enlarged to 5,000 acres and managed similar to Gray Lodge.

Another area on upper Butte Creek of about 5,000 acres is proposed and will be managed and developed similar to the others.

Suisun Bay: At present the State Suisun Refuge comprises 1,800 acres on Joyce Island. Grizzly Island Management area will be developed nearby and will cover approximately 8,600 acres on which duck feed will be grown to hold large concentrations of birds from moving onto the croplands of the Delta Islands and lower Sacramento Valley. It will also be managed for public shooting.

San Joaquin Valley:

1. Los Banos State Refuge is at present the only public waterfowl area in the entire San Joaquin Valley. It is proposed to increase this to 6,500 acres and to develop it for waterfowl food and public hunting.
2. Federal government proposes to buy and develop a management area in Merced County, approximately 11,000 acres in extent, primarily for the protection of crops from geese.
3. In the Madera-Fresno district, the state plans to establish a new waterfowl management unit of approximately 5,500 acres for the protection of rice crops and to provide public shooting in that area.
4. In Kern County a management area of 6,500 acres

GREY LODGE REFUGE

At the present time (1950)
consists of 2542 acres.

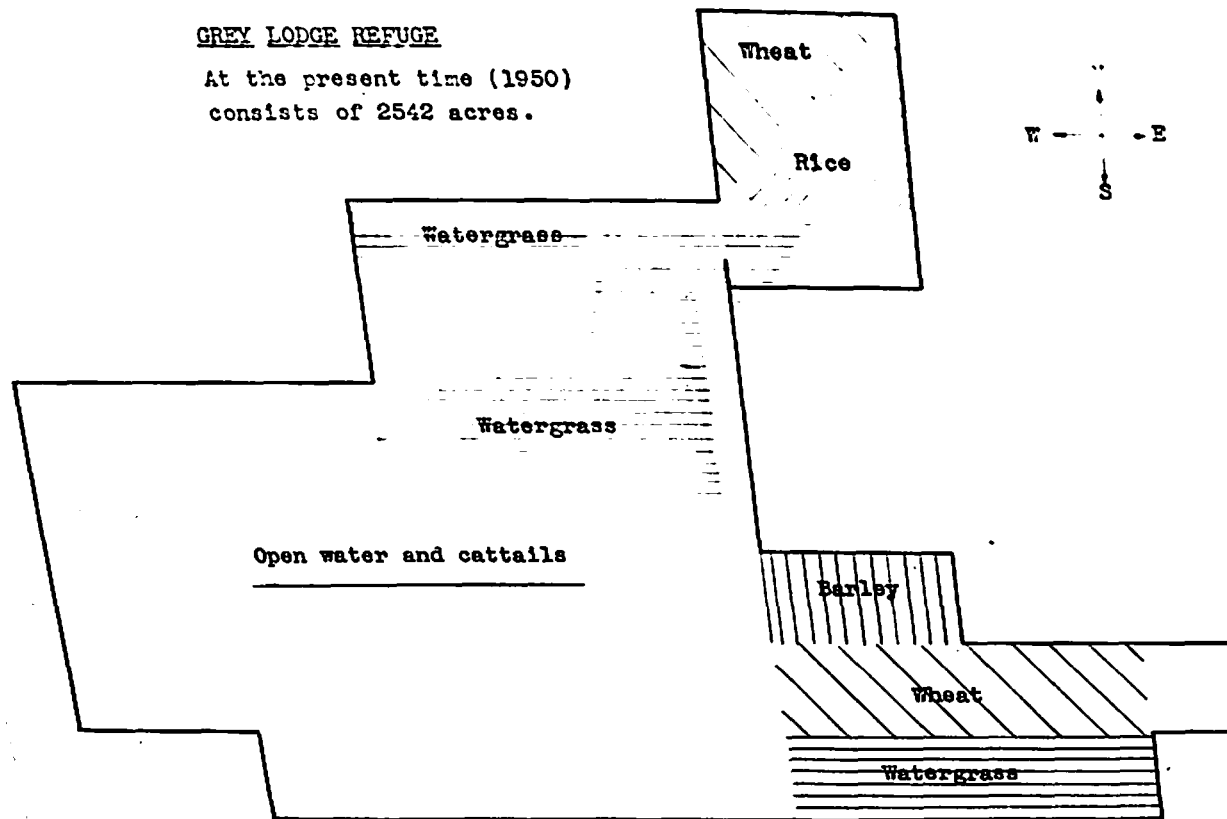


Figure 18. Outline sketch of Grey Lodge Refuge showing approximate plan for agricultural crop production to hold birds off commercial croplands.

Figure 19. Portion of Gray Lodge Refuge as shown from this aerial photograph is certainly a waterfowl haven. This picture was taken when approximately $1\frac{1}{4}$ million birds were using it for a feeding and resting area. Dark and light spots are birds. Courtesy California Division of Fish and Game. (Photo by John Chattain, 1949)

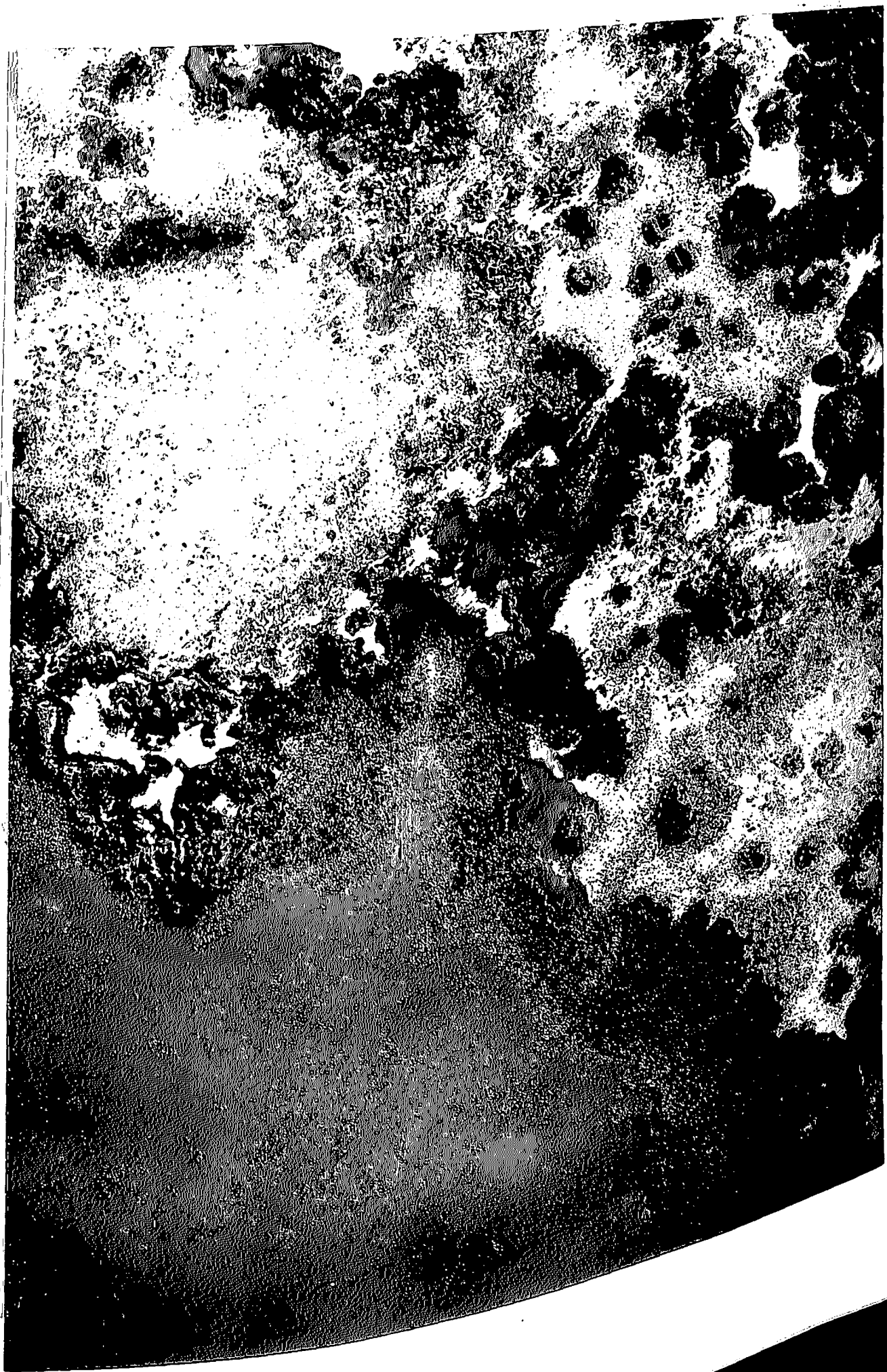




Figure 20. This picture shows thousands of waterfowl resting and feeding on Grey Lodge Refuge near Gridley, California. This will soon be enlarged and made into a public hunting ground during part of the hunting season. (Photo by John Cowan, 1949)

has been proposed to provide an artificial resting, feeding and hunting place for birds in the place of the dry former Tulare and Buena Vista Lakes.

Imperial Valley: The Salton Sea Refuge was established in 1930 and comprises 32,407 acres of little more than a fair resting place for waterfowl. Birds raft in great numbers in the middle of the Salton Sea during the day and feed on the farmers' crops during the night. Since 1947 12,000 acres have been provided for raising waterfowl food similar to surrounding crops and for providing a hunting area for the unattached hunter. The program underway at the present time calls for an additional 12,000 acres. The State is developing these lands with Pittman-Robertson funds, and the Federal government is using Lea Act money in its part of the program.

SUMMARY OF DAMAGE BY WATERFOWL

Each year many millions of waterfowl migrate into California for the late fall, winter and early spring months. While they are here they are causing considerable crop damage in many areas of the state which was estimated to be over one and one-half million dollars in 1943. These birds also furnish recreation in the form of hunting to over 200,000 people in California alone during the waterfowl season. In the 1948-1949 season 2,855,000 ducks, 344,000 geese and 116,000 coots were legally killed and presumably put in the pot or the roasting oven. (Chattin, 1949) This would approximate a value of over \$4,000,000 worth of meat annually. The amount spent by waterfowl hunters each year in the pursuit of this sport, which has been estimated at over \$2.00 for every duck shot and \$5.00 for every goose shot, totals over \$7,500,000. Untold millions of harmful weed seeds and undesirable insects are eaten by waterfowl each year. (Henderson, 1934, p. 144)

From this it can be seen that a large waterfowl population is economically justified even in the face of large crop losses. It is equally apparent that individual farmers should not have to provide feed for these birds each year and consequently to suffer large monetary losses. The farmer does not want to see the birds killed; most farmers enjoy the sport of hunting ducks and geese themselves, but

they do want adequate protection from these birds until after their crops are harvested.

The present management plan for controlling the problem of waterfowl damage in California has been very successful and this program will be expanded in the near future. If this program is successful it will accomplish three main objectives:

1. By growing waterfowl food crops and flooding these crops during the time of commercial crop damage, waterfowl can be more easily kept off the farmers' fields by frightening devices and herding.
2. More and better hunting areas will be made available to the unattached hunters and to the man with a smaller pocketbook.
3. The present numbers of waterfowl will be assured of more adequate feeding and resting areas in their wintering grounds here in California by partial replacement of their lost marshes; and the waterfowl of the Pacific Flyway will have a brighter outlook for the future.

The success or failure of this plan is dependent largely upon an adequate supply of water now and in future years. As the demands for water increase, stricter regulations will be imposed until all of the water in our rivers, streams and canals will be controlled and allotted for specific purposes. A statement made by Horn, (1949, p. 578) disclosed that under present state water codes, the

need for neither fish nor wildlife are recognized as a primary use for water. This should be corrected to meet the needs of our wildlife resources as well as our agricultural and industrial resources.

The pattern for controlling waterfowl depredations has been made. If this pattern can be followed in future years, the farmer, the sportsmen and the waterfowl will benefit by it greatly; and the Federal and State agencies involved will have solved one of the major problems of waterfowl management.

SUMMARY AND CONCLUSIONS

The important factors brought out in this study of crop damage by deer and waterfowl and methods for control in California may be summarized as follows:

1. The population of deer in California has more than doubled during the past half century and are estimated to be between 750,000 to 1,000,000 at the present time, 1950. The population of migratory waterfowl wintering in California is believed to be approximately seven million birds. In many areas of the state both deer and waterfowl include agricultural crops as a part of their diet. This has resulted in economic losses to the farmer which has been termed crop damage.
2. The principal causes of crop damage by deer are the increase of deer populations, the reduction of natural feed and watering areas brought about by the settlement and economic development of California, mainly agriculture, and the planting of crops within the limits of deer range.
3. The principal causes of crop damage by waterfowl in California are the reduction of natural feeding and resting areas, which was accomplished by draining most of the marsh areas; and the planting of agricultural crops in their stead. In the Imperial Valley, damage was caused by the creation of the Salton Sea by floodwaters of the Colorado River which attracted a large number of waterfowl

and the growing of agricultural crops by irrigation in an area that was once a barren desert.

4. Crop damage by deer occurs to some extent in forty-five of the fifty-eight counties; but the main areas of damage are in the Capay Valley, Yolo County; in the Auburn area of Placer County; in Priest Valley, Monterey County; Modoc County; in the Ojai and Piru section of Ventura County; in the Napa Valley of Napa and Sonoma County; and home gardens of Marin, Alameda, and Contra Costa Counties.

5. The main waterfowl damage areas are the Tule Lake section of Siskiyou County; the Sacramento and San Joaquin Valleys in the northern and central part of the state; and the Imperial Valley in the south.

6. Deer, which are resident game, cause damage the year around to some extent. However, most of the damage occurs during the late spring, summer and early fall months when rainfall is at a minimum. Damage is reported most often to orchard, vineyard, and truck crops with citrus, pasture and miscellaneous crops coming next in that order.

7. Waterfowl, which are migratory game, cause damage mainly from the time they come into California in early August until they leave again in the spring. Most of the damage occurs in the late summer and in the winter months. Heaviest damage is reported on rice, barley, lettuce, wheat, alfalfa, pasture, and clover; and the worst offenders are Mallards, Pintails, and Widgeon; White-fronted, Cackling,

Lesser snow and Canada geese; and coots or mudhens.

The control of waterfowl damage is accomplished by the use of frightening devices of various types; systematic herding from the ground and by airplane; and by providing management areas where food crops are grown and flooded at the time of damage to supply adequate feeding and resting places for the birds as well as a suitable hunting ground for the public. It is the conclusion of the writer that these feeding and resting areas will eventually solve the greatest part of the problem of waterfowl depredation in California. At the present time these areas are inadequate in both size and number.

The control of deer damage in California is attempted by fencing, spraying, trapping and transplanting which are all very costly and in many instances impractical; by killing deer that are causing the damage, which is legal under the present law if a permit is obtained. This method is also impractical and only a temporary control.

It is the conclusion of the writer, based on his recent studies, that if these methods of reducing deer damage are continued without the systematic and controlled reduction of our deer population, the solution of the major part of our crop damage will never come to full realization. The most satisfactory and most efficient method of controlling the deer population is to have an open season on antlerless deer in those sections of California where control is needed.

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