Agricultural Land Use and Wildlife in the San Joaquin Valley, 1769-1930:

March 1988

An Overview

Prepared under contract for the

Federal/State
SAN JOAQUIN VALLEY
DRAINAGE PROGRAM

This report presents the results of a study conducted for the Federal-State Interagency San Joaquin Valley Drainage Program. The purpose of the report is to provide the Drainage Program agencies with information for consideration in developing alternatives for agricultural drainage water management. Publication of any findings or recommendations in this report should not be construed as representing the concurrence of the Program agencies. Also, mention of trade names or commercial products does not constitute agency endorsement or recommendation.

The San Joaquin Valley Drainage Program was established in mid-1984 as a cooperative effort of the U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, U.S. Geological Survey, California Department of Fish and Game, and California Department of Water Resources. The purposes of the Program are to investigate the problems associated with the drainage of irrigated agricultural lands in the San Joaquin Valley and to formulate, evaluate, and recommend alternatives for the immediate and long-term management of those problems. Consistent with these purposes, Program objectives address the following key areas: (1) Public health, (2) surface- and ground-water resources, (3) agricultural productivity, and (4) fish and wildlife resources.

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INTRODUCTION

In 1983 U.S. Fish and Wildlife biologists discovered deformed and dying waterfowl at Kesterson National Wildlife Refuge in the San Joaquin Valley, California. Tissue analysis revealed that naturally occurring inorganic substances, particularly selenium, contributed to or caused the deformities and deaths. Further investigations determined that the inorganic substances were deposited in holding ponds by agricultural drainage waters that seeped or flowed into the refuge. The existing and potential threat to wildlife provoked studies whose purposes have been to verify original findings, and to suggest remedial actions that could be followed to protect wildlife in the refuge and within its environs. This baseline report adds to the series of investigations by placing the subjects of agricultural land use and wildlife in the San Joaquin Valley within an historical context.

This study focuses on the growth of the agricultural sector in the valley, and suggests how rural development and land use impacted wildlife by altering habitat and by other means. The time frame embraced by this report is inordinately long (stretching over several million years), but this is necessary for the reason that representatives of the San Joaquin Valley Drainage Program felt that conditions present in the valley's pristine environment should be the basepoint for the beginning of a land use review. The year 1930 has been chosen as the terminal date for this paper because artificial stimulants contributing to

the growth of the agricultural sector, i.e., federal government programs designed to stabilize production and encourage rural settlement, began in earnest in the 1930's, and serious efforts to plan for development of the state's water resources began about this same time. Actual construction of the Central Valley Project and State Water Project were, of course, delayed for several more years.

This report begins by presenting a review of the geologic formation of California generally, and the San Joaquin Valley particularly. Statements will follow on the subjects of climate and the floral and faunal communities as they are thought to have existed over pre-historic time. An effort will be made to picture the pristine waterscape. We will then examine soil types, and review an early attempt to classify agricultural lands within the valley.

Alterations to the landscape due to human influences began about 10,000 years ago with migrations of Asian peoples into California. But the impact of these hunters and gatherers seem slight when compared to modifications made to the landscape after the Spanish entered California. After 1769, but before the beginning of the Gold Rush in 1849, grazing feral Spanish livestock, combined with the forces of nature, encouraged the growth of introduced floral species. Successions took place. The landscape so often commented upon by gold seekers and other mid-Nineteenth Century adventurers was not, therefore, the same as that viewed by earlier inhabitants. Comments will be made

regarding changes that occurred in the geoflora over the San Joaquin Valley.

More dramatic changes to both water and landscapes took place following immigration and settlement after 1849. For reasons that will be explained, the lower San Joaquin Valley felt the impact of new settlement to a greater degree than did the upper valley. We will examine why and how this happened, and the effects of settlement and development on the natural resource base.

The bulk of the report that follows will be devoted to an examination of the growth of the agricultural sector within the valley between 1870 and 1930. Mention will be made of cropping patterns, means of production, land use, water use, and how they singly, and in combination, impacted wildlife. But human occupancy alone did not alter the valley land and waterscapes. Nature repeatedly adjusted landforms and waterways through climatic changes and by floods. Reference will be made to particular events, and examples given to demonstrate how nature changed the landscape.

A provision for this report is that mention be made of the activities of hunters and trappers, and their influences on wildlife populations. This will be accomplished in the last paragraphs of this study.

This report specifically focuses on activities taking place within the San Joaquin Valley. This valley is herein defined as that area bordered on the north by the Delta Region, on the east by the foothills on the western flank of the Sierra Nevada

Mountains, on the south by the base of the Tehachapi Mountains, and on the west by the foothills of the Coast Range of Mountains. Descriptions of the flora and fauna relate specifically to the area hereafter defined in this report as the Lower Sonoran Life Zone.

There are certain limitations that impose themselves upon a study of the type undertaken here. A foremost handicap is the fact that detailed descriptions and data relating to land use, water resources, the geographic distribution and extent of wetlands and overflow lands, stream measurements, water quality, and wildlife populations (including their areal distribution and habitat type) are in general missing for the early period described in this study. Clues offered by travelers are often the only evidence available. But comments made by travelers and early California residents are circumspect, since they were not generally trained observers; and they often overstated observations.

Reports and discussions among bird watchers and other naturalists provide valuable clues as to the status of wildlife in early California. It is a regrettable fact, however, that bird watching, and observations made by early-day naturalists, centered more in the coastal regions and the Sacramento Valley than in the San Joaquin Valley. Why this occurred can be explained only in part by suggesting that early settlement concentrated in these areas and, perhaps, wildlife was more abundant along the coast and in northern California than in the semi-arid San Joaquin Valley, in the Lower Sonoran Life Zone.

The relative scarcity of observations in the San Joaquin Valley has restricted data gathering for this study.

United States census data have shortcomings too. The problems arising from incomplete data will be mentioned in the text.

A third problem that restricts accurate assessments of man-land relations to wildlife in the San Joaquin Valley is the fact that certain species, specifically migratory waterfowl, were not endemic to the valley. We must recognize, therefore, that influences governing migratory fauna populations originated outside the valley as well as within its confines. This being the case, we cannot state with authority how activities within the San Joaquin Valley impacted migratory wildlife populations as a whole.

Acknowledgment is hereby given to those who have provided assistance and encouraged the research and writing of this report; particularly Henry L. Hansen, Robert L. Horton and Stephen B. Moore, staff members in the San Joaquin Valley Drainage Program. Patti Tift typed the manuscript.

PHYSICAL ENVIRONMENT

One hundred and thirty-five million years ago, during the Mesozoic Era late Cretaceous Period (Figure 1), a low range of mountains separated the Great Basin from the Pacific Ocean. In some areas on the western flank of these mountains sharp escarpments overhung the ocean. In other places, fingers of land formed of silt washed off hillsides by ancient rivers thrust their way into the sea. A parallel trough abutted the mountain range and separated the mainland from islands laying several miles to the west. This island chain, about twenty miles wide at its northern extreme, emerged from the ocean at a point south of Livermore, followed a southeasterly course, and terminated west of Tulare Lake Basin.

In the middle Tertiary Period tumultuous activity within the earth's interior caused the Sierra Nevada to rise. This pulled the western flank of the mountain chain above sea level, and portions of the adjacent ocean floor may have been uplifted at this time too. Subsequent earth activity resulted in further uplifting and deforming of the off-shore trough (the San Joaquin geosyncline). The ocean floor rose further, a land bridge formed, and the off-shore chain of islands became the present day Coast Range and coastal valleys.

Later earth movements along fault lines interspersed within the recently formed valley caused further folding. A portion of the valley floor, beginning at about Mendota and extending north to the Delta region, raised and a transectional lobe appeared

that stretched across the valley from a point southeast of Mendota to the Coast Range of Mountains. The presence of this transectional lobe did not at that time greatly impact either the landscape nor the waterscape within the valley, for the trough was covered by a massive inland salt water lake. (Figure 2) The floor of the lake at that time was probably near its present height on the north end of the trough. On the southern end, the lake's floor may have been two to three thousand feet deep.[1]

Subsequent earth movements further affected the San Joaquin Valley landscape. First the earth separated to open Carquinez Straits, and a portion of the great inland lake poured into San Francisco Bay. Fresh water flowing off the Sierra Nevada incline, which earlier had debouched into the lake, now flowed to the Bay, purging the saltwater from the lower valley as it traveled north. Subterranean earth movements then opened the Golden Gate. Drainage from the valley was thereafter affected by ocean tidal flows.

Glaciers moving south during the Pleistocene Epoch, popularly known as the Ice Age, did not modify landforms in the San Joaquin Valley, for they never descended as far south as California. However, weather changes did occur, and became especially severe in the Sierra Nevada. As a result, glaciers formed in the higher mountain regions.

The San Joaquin Valley had been largely formed by the end of the Pleistocene Epoch. Approximately 260 miles long and 130 miles wide, it covered an area of some 32,000 square miles, or about one-fifth of the land surface of California. Within these

greater dimensions lay the valley floor that extended over an area of about 13,000 square miles. The transectional lobe divided the valley north and south, with the northern portion, the lower valley, being nearer sea level. The northwest flowing San Joaquin River, beginning at Herndon and extending to the Delta Region, formed an axis that divided the valley east and west.

Within the lower valley, on the east side, extensive foothills covered the western flank of the Sierra Nevada. Snow-fed mountain streams with deep bottoms partitioned foothill lands as they flowed toward the valley. High encasing bluffs along major streams tended to discourage erosion of the mountain sides. As a result, large streams did not form great alluvial fans when they debouched into the valley. Rivers emerging from the foothills did bifurcate, but not to the degree that streams did in the upper valley. The three major streams, the Merced, Stanislaus and Tuolumne, and several more modest rivers, purged their waters into the northwest flowing San Joaquin River, whereby they had an outlet to the sea.

The Tertiary uplift treated the southern Sierra Nevada more severely than the northern portion. Once rounded hillsides were thrust into the air, and steep mountainsides formed. As the weather warmed following the Pleistocene Epoch, ice packs melted and fed streams that became torrential. Great amounts of erosion occurred, and rocks, gravel and sediment pushed down the steep slopes. Over aeons of time, streams guided these materials through deeply forming canyons to the valley below. Gradually,

the great cavity in the upper valley floor filled. Ever increasing deposits of sediments pushed the trough to the west, and began filling in lands to the east where, eventually, they abutted the mountains. The foothills nearly disappeared. Deposits from the Kings River settled upon the ridge of the transectional lobe increasing its height. This cut the rivers of the upper valley off from an outlet to the sea. As the alluvial fans pushed ever closer to the Sierra Nevada, the streams lost their ability to cut deep bottoms. Thereupon, they debouched over the fans through a myriad of creeks or sloughs. During periods of low stream flow, large amounts of water sank into the earth. In periods of high water the saturated soils in the fans repelled the overflow, and waters moved further west into shallow depressions: permanent fresh water lakes with highly variable shorelines, known as Kern, Buena Vista and Tulare Lakes. (Figure 3)

The presence of streams along the hillsides and alluvial fans on the east side of the San Joaquin River did not at all reflect developments on the west side of the river. The latter area, smaller by about forty percent than its eastern counterpart, lay within the rainshadow of the Coast Range. Streams did not run perennially, and only small alluvial fans formed on the valley's west side.

CLIMATE

Dramatic climatic changes accompanied the geophysical metamorphosis taking place during and following the Tertiary Period. The climate during the Miocene Epoch, and for at least part of the Pliocene Epoch, appears to have been more uniform than now. During the Pleistocene Epoch, the climate cooled as glaciers flowed south. Once the glaciers receded, however, periods of shortened rainfall began. Precipitation lessened in the winter, and virtually ended during summer. As the weather warmed, rainfall declined still more, and at some time several thousand years before recorded history, California supported hot summers with periods of severe and recurring drought, unpredictable winter rainfall, and at times, floods devastated the landscape. Within the San Joaquin Valley, precipitation diminished from north to south, with the northern section receiving, in a normal year, fifteen inches of rain, while in the upper valley five inches of annual rainfall created an arid landscape. (Figure 4) Over the next several thousands of years further adjustments led to the present day pattern of climatic regions in California. (Figure 5)

FLORA[2]

Climate is not the sole factor in determining vegetative cover, although it remains a major consideration. Biologists at

an early date recognized that a means must be conceived to express the influences of climate on life forms. They therefore created a descriptive system known as Life Zones. (Figure 6)

Briefly stated, C. Hart Merriam, a biologist with the Biological Survey, U.S. Department of Agriculture, divided all life areas in extra tropical North America into two great provinces: the Boreal and the Sonoran. Within California, one Boreal Province is represented along the coast by the Coast Range of Mountains. The Sierra Nevada Mountains form a second Boreal Province. The state has been further divided into two Sonoran Provinces: one represented by an area including the Colorado Desert, the Great Basin and Southern California; the Central Valley is the second Sonoran Province of California. Later refinements to the Life Zone concept further divided the Central Valley into five sub zones: the Lower Sonoran, the Upper Sonoran, the Transition, Boreal and Alpine Zones.(3) (Keeler, 1890)

Plant species(4) in the early Tertiary Period were richer and more varied than now. An Arcto-Tertiary geoflora, a heavily forested area, existed north of San Francisco and extended into the Arctic region. From San Francisco to the south, and perhaps extending into South America, subtropical trees such as figs, avocados, cinnamon and palms comprised a Neotropical Tertiary geoflora.

In the middle Miocene Epoch climatic changes reduced or eliminated much, if not all, of the subtropical vegetation, and a different geoflora appeared. Termed the Madro-Tertiary geoflora,

it consisted of an oak woodland and schlerophyllous: small-leafed trees and shrubs that may have been the ancestors of present day chaparral and sagebrush species. The oak woodland, in turn, declined during the middle of the Pliocene Epoch to be replaced during the Pleistocene and later periods by plants that persisted and were present when the Asian populations arrived in California several thousand years later.

A splendid variety of plants covered the California landscape prior to Spanish settlement. Ornduff (1974) calculates the presence of over 5,000 native vascular plants in 162 families in the pristine period. Within the area commonly referred to as the valley grassland and foothill-woodlands, which exist within the Lower Sonoran and Upper Sonoran Life Zones (Figure 7), there existed a continuum of species represented by such plants as Purple Stipa (Stipa pulchra), Nodding Stipa (Stipa cernua), Pine Bluegrass (Poa scabrella), Blue Wildrye (Elymus glaucus), California Melic (Melica californica), Small-flowered Melic (Melica imperfecta), California Brome (Bromus carinatus), Junegrass (Koelaria cristata), California Oatgrass (Danthonia californica), Big Squirreltail (Sitanion jubatum), and Beardless Rye. (Crampton, 1974; Burcham, 1957) A few annuals existed within this pristine florascape: the Small Fescue (Festuca microstachys), Sixweeks Fescue (Festuca octoflora), Scribneria (Scribneria bolanderi), and in the upper valley or Tulare Basin, Arizona Brome (Bromus arizonicus). Families of broad-leaved forbes, Compositae, Leguminasae, Boraginaceae, Schrophalariaceae

and Popaveraceae also blossomed within the grassland-foothill area.

Wetland areas, variously described as covering from one to five million acres within pristine California, supported communities of moisture loving plants. Within the Delta in the northern San Joaquin Valley, in and around the lakes in the upper valley, and along streams and sloughs, grew Creeping Wildrye (Elymus triticoides), Slender Wheatgrass (Agropyrom Subsecundum), Meadow Barley (Hordeum brachyantherum), Deergrass (Muhlenburgia rigens), Pinegrass (Calamagrostis rubescens), Prairie Wedgegrass (Sphenopholis obtusata), and a somewhat mysterious and yet to be identified species described by Cronise (1870) as an indigenous millet or rice that attracted millions of geese and ducks to the state's winter feeding grounds.

Wetlands are gaining respect from urbanites who think that cattails, bulrushes and tules may in the future serve as natural waste-treatment plants. (Tribune, 1987) Early travelers had less respect for these species. John Woodhouse Audubon (1906), for example, grumbled in 1849 that bulrushes infesting overflowed lands adjacent to the San Joaquin River prevented his party from obtaining feed and water. He further lamented that his party had to travel for miles over bulrush lands to reach the river. Experts currently identify these and other wetland species as the tall rush (Scurpus lacustrus), tules (Scirpuss spp., Cyperaceae), cattails (Typha spp., Typhaceae) and sedges (Carex spp., Cyperaceae); quickly multiplying species that have in the past covered areas along the valley's fresh water streams and marshes.

Perennials represented within the riparian plant communities included the Tufted Hangrass (*Deschampsia caespitos*), Spike Bentgrass (*Agrostis exarata*), Reed Canarygrass (*Phalaris arundinacea*), Knotgrass (*Pasplalum distichum*), Foxtail Barley (*Hordeum jubatum*), the Common Reed (*Phragmites australis*), and Rye Cutgrass (*Leersia oryzoides*). Annuals enhancing the waterscape included Sloughgrass (*Beckmannia syzigachne*), Bogrush (*Juncus effusus*), and Tall Rush (*Scurpus lacustris*). (Crampton, 1974)

J.W. Congdon (1893) compiled a list that included thirty-three plants, all thought to be native, that grew along the Merced River, or in communities in and about damp locations that bordered the river. Two species identified by Congdon that are rarely mentioned in lists of riparian vegetation were the Syringa (*Philadelphus levissi*) and the California Strawberry Tree (*Calycanthus occidentalis*), which, the naturalist said, were especially plentiful along the river's banks. Streamside trees identified by Congdon included alders (*Alnus rhombifolia*) so great in size that they stood "...often sixty feet high and [are] a foot in diameter...", and the tree willows (*Salix laevigata* and *S. nigra*).

As temperatures dropped during the Pleistocene Epoch, various species of trees migrated to warm niches on the western flank of the Sierra Nevada where they survived until the glaciers receded. They subsequently spread to forest the Sierra Nevada, and a few species migrated to the Coast Range of Mountains. With the exception of one or two instances, the grasslands remained

virtually treeless except in gullies, along watercourses and in and about wetlands. Within the latter two areas, California Sycamore (Platanus racemosa), the Cottonwoods (Populus spp.), Fremont Poplar (Populus fremontii) and, of course, the willows manifested themselves.

In the low-laying, poorly drained and alkali infested areas, especially within the Tulare Basin, halophytic or salt tolerant plants thrived. Characteristic species growing in this area included the saltbush (Atriplex spp.), Iodine Bush (Allenrolfea occidentalis), pickleweed (Salicornia spp.), Greasewood (Sorcobatus vermiculatus) and seepweed (Suaeda spp.). (Ornduff, 1974).

Two deviant plant communities, one a sagebrush area near Buena Vista Lake, the other vernal pools or "hog wallows", existed within the grassland and foothill-woodland complexes. It appears in the first instance that the sagebrush around Buena Vista Lake was a coastal sagebrush; a community of half-shrubs or subshrubs. Principal flora types were the California Sagebrush (Artemisia californica), white, black and purple sages (Salvia apiana; S. mellifera; S. lencophylla), Coyote Brush (Baccharis pilularis), California Buckwheat (Criogonum fasciceelatum), Sawtooth Golden Bush (Haplopappus squarrosus), Golden Yarrow (Eriophyllum confertifolium), Lemonadeberry (Rhus intergrifolia), and Laurel Sumac (R. laurina). It is not apparent which of these species dominated. (Burcham, 1957)

There is doubt about the origin of the vernal pools or hog wallows that dotted the San Joaquin Valley landscape. One

seasoned geologist thought they were the homes for colonies of ground squirrels, but this has yet to be confirmed. (Boulger, 1938) E.W. Hilgard did not so speculate. Instead, he described the soils surrounding the vernal pools located near Visalia as being dry bog, adobe, deeply fissured during the dry season, and spotted with concentrations of bog ore or "black gravel". (U.S. Census, 1884) The vernal pools commonly had sides about one foot high and were fifteen to twenty-five feet in diameter. During the winter the pools filled with water, and because hog wallows drained poorly, they retained some moisture into the spring and summer seasons after surrounding soils dried. Bakker (1984) suggests that vernal pools supported plant communities where 200 species thrived.

Annuals only grew in vernal pools. Representative species were Boisduvalia cleistogama, B. glabella var. compestris, Navarettia leucocephala, Downingia elegams, D. ornatissima, Mimulus tricolor, Lepidium latipes, Psilocarphus brevissimus, Lythrum californicum, Oricuttia californica, Juncus bufonius, and Lolium temulentum. (Klyver, 1931)

Trees appearing on the grasslands included a stand (three to four trees to an acre) of White Oak (Quercus lobata) growing on the Kaweah River alluvial fan around present Visalia. Interior Live Oak (Q. wislizenii) could be seen near streams. And in the higher elevations, within the foothill-woodlands, grew the Blue Oak (Q. douglasii) and the Engleman Oak (Q. engelmannii).

FAUNA

Remains of land mammals occupying the San Joaquin Valley prior to the Recent Epoch are scarce. To 1942 paleontologists identified three extinct mammal fauna dating from the Pliocene Epoch in the Kern River Divide: Pliohippus, Merycodus, and Bassariscus antiquus. (Miller and May, 1942) Conversely, shark's teeth dating from the Miocene Epoch have been found by the hundreds at Shark Tooth Hill, seven miles northeast of Bakersfield on the Kern River.

Avifauna constitute the remaining discoveries to 1942. Paleontologists recovered several species at Shark Tooth Hill, at McKittrick, from the drill core of a well, and on the Kern river Divide, all in Kern County. Avian species removed from Sharktooth Hill, now all extinct, included Puffiunus inceptor, Puffinus sp., Moris vagabundus and Presbychen abavus. One avian species was identified as the extinct Sarcoramphus kernensis, located in the fresh water Pliocene bed on the Kern River Divide near Poso Creek. Another recovered fragment represented a buteonid hawk, but could not be positively identified as Parabuteo spp. The core sample from the oil well in Kern County contained remains of the extinct Colymbus parvus, dating from the Pliocene Epoch.

The dig at the McKittrick tar pits, dating from the Pleistocene Epoch, uncovered seventy-one recognized species of avifauna, and one that experts tentatively identified as a Pintail (Dafila acuta). Of the seventy-one species, only ten

were extinct. This seems to confirm the belief that avifauna have, over time, experienced fewer evolutionary changes than did mammal fauna. (Ibid.) Table 1 lists the Pleistocene avifauna located at the McKittrick site prior to 1942.

Table 1. Avian Species From McKittrick Site*

Pied-billed Grebe (Podilymbus podiceps)
Great Blue Heron (Ardea herodias)
Black-crowned Night Heron (Nycticorax nycticorax)
Heron, indeterminate ***
Asphalt Stork (Ciconia maltha) **
Whistling Swan (Cygnus columbianus)
Canada Goose (Branta canadensis)
Dickey's Goose (Branta dickeyi) ** ***
Brea Pigmy Goose (Anabernicula minuscula) **
Snow Goose (Chen hyperborea)
Mallard (Anas platyrhynchos)
Gadwall (Chaulelasmus streperus)
Baldpate (Mareca americana) ***
Pintail (Dafila acuta) (?) ***
Green-winged Teal (Nettion carolinense)
Cinnamon Teal (Querquedula cyanoptera) ***
Shoveler Duck (Spatula clypeata)
Red-head (Nyroca americana) ***
Lessor Scaup Duck (Nyroca affinis) ***
Buffle-head (Charitonetta albeola)
Ruddy Duck (Erismatura jamaicensis) ***
Anserines, indeterminate ***
Turkey Vulture (Cathartes aura)
Western Black Vulture (Coragyps occidentalis) **
Merriam's Teratorn (Teratornis merriami) **
Errant Eagle (Neogyps errans) **
American Neophron (Neophrontops americanus) **
Cooper's Hawk (Accipiter cooperii)
Red-tailed Hawk (Buteo jamaicensis)
Swainson's Hawk (Buteo swainsoni)
Ferruginous Rough-leg (Buteo regalis)
Hawk (Buteo sp.)
Fragile Eagle (Hypomorphnus fragilis) **
Golden Eagle (Aquila chrysaetos)
Bald Eagle (Haliaeetus leucocephalus)
Marsh Hawk (Circus hudsonius)
Rancho La Brea Caracara (Polyborus p. prelutosus) **
Prairie Falcon (Falco mexicanus)
Swarth's Falcon (Falco swarthi) ** ***

Table 1. (Continued)

Duck Hawk (*Falco peregrinus*)
Pigeon Hawk (*Falco columbarius*)
Sparrow Hawk (*Falco sparverius*)
Falcon (*Falco sp.*)
California Quail (*Lophortyx californica*)
Little Brown Crane (*Grus canadensis*)
Virginia Rail (*Rallus limicola*) ***
Mountain Plover (*Eupoda montana*) ***
Killdeer (*Oxyechus vociferus*)
Greater Yellow-legs (*Totanus melanoleucus*)
Long-billed Curlew (*Numenius americanus*)
Red-backed Sandpiper (*Pelidna alpina*) ***
Dowitcher (*Limnodromus griseus*)
Charadriiformes, indeterminate
Morning Dove (*Zenaidura macroura*)
Road-runner (*Geococcyx californianus*)
Great Horned Owl (*Bubo virginianus*)
Burrowing Owl (*Speotyto cunicularia*)
Long-eared Owl (*Asio wilsonianus*)
Red-shafted Flicker (*Colaptes cafer*)
Horned Lark (*Otocoris alpestris*)
Cliff Swallow (*Petrochelidon albifrons*) ***
California Jay (*Aphelocoma californica*)
Magpie (*Pica sp.*) ***
Raven (*Corus corax*)
White-necked Raven (*Corvus cryptoleucus*)
Cactus Wren (*Hebeodytes sp.*) ***
Bendire's Thrasher (*Toxostoma bendirei*) ***
Sage Thrasher (*Oreoscoptes montanus*)
Loggerhead Shrike (*Lanius ludovicianus*)
Western Meadowlark (*Sturnella neglecta*)
House Finch (*Carpodacus mexicanus*) ***
Bell's Sparrow (*Amphispiza belli*)

* Miller and DeMay, 1942.
** Extinct species.
*** Species located only at McKittrick prior to 1942.

The presence of native fish and amphibians in California waters attracted less attention during the Nineteenth Century than did the populations of mammals and avifauna. The descriptive literature is as a result not voluminous.

When the Tertiary uplift occurred, it may have confined salt waters within the San Joaquin Basin. The areal extent and the volume of the captured waters is not know. Evidently, salt water fishes did inhabit these waters for some time, as the evidence uncovered at Shark Tooth Hill in Kern County demonstrates. Additional evidence showing that fresh water lakes extended over at least part of the area during the same epoch suggests that the deaths of salt water fish and, perhaps, the infusion of fresh water species occurred within a comparatively short period of time.

Of the twenty-two species of fresh water native fish listed by Cloudsley Rutter (1908), twelve were typical of, and had wide distribution within the San Joaquin Basin. The following table lists seventeen species.

Table 2. Representative Native Fresh Water Fishes Appearing in the San Joaquin Basin Before 1908. *

Western Sucker (*Castostomus occidentails*)
C. areopus
Greaser Blackfish (*Orthodon microlepidotus*)
Lavinia exilicauda
Bluefish; hardhead (*Mylopharodon conocephalus*)

Table 2. (Continued)

Split-tail (Pogonichthys macrolepidotus)
Sacramento Pike (Ptychocheilus grandis)
Sacramento Chub (Leuciscus crassicauda)
Leuciscus conformis
California Roach (Rutilus symmetricus)
Agosia robusta
Rainbow Trout (Salmo irideus)
Golden Trout of South Fork of Kern River (Salmo agua-bonita)
Stickleback (Gasterosteus cataphractus)
Sacramento Perch (Archoplites interruptus)
Fresh-water Viviparous Perch (Hysterocarpus traskii)
Sculpin; Bull-head (Cottus gulosus)

* Rutter, 1908.

Following the opening of the Golden Gate passage, anadromous fishes migrated into the bay and established runs on the larger streams in the Central Valley. (Figure 8) Early evidence reveals that anadromous species made spring and fall runs on the Sacramento River system, and late runs only on the San Joaquin River system. The species occupying rivers within the San Joaquin River Basin were also a smaller fish. (San Francisco Chronicle, 1879) Interestingly, Rutter did not list one species of anadromous fish with a type locality in the San Joaquin River Basin.

The Tulare Basin supported a large fresh-water fish population before, and for several years following American settlement. (Latta, 1937A) Periodic restocking of Tulare Lake occurred during periods of overflow when thousands of fish were swept into the valley by rapidly flowing Sierra Nevada streams.

Anadromous fishes also appeared in the lake at times when overflow waters ran north from Tulare Lake, through Fresno Slough and into the San Joaquin River. The only salmon endemic to the Tulare Basin was the Golden Trout on the South Fork of Kern River (Salmo aqua-bonita). Of casual interest only is the fact that Tulare Lake became well known for terrapin. It has been said that the terrapin were of such quality that they set the standard for the gourmet soups made in San Francisco.

Amphibians and reptiles inhabiting the Lower Sonoran Life Zone were comparatively scarce. Two lists published at the beginning of this century list thirteen species, all of which, with the exception of the Eastern Bullfrog (Rana catesbeiana), are native but not endemic to the area.

Table 3. San Joaquin Valley Amphibians and Reptiles Listed By Grinnell and Camp, and Storer.*

California Tiger Salamander	(Ambystoma californiense)
Western Spadefoot Toad	(Scaphiopus hammondii)
California Toad	(Bufo boreas halophilus)
Pacific Tree-toad	(Hyla regilla)
Eastern Bullfrog	(Rana catesbeiana)
Tiger Salamander	(Amtystoma tigrinum)
Southern Brown-shouldered Lizard	(Uta stansburiana hesperis)
California Whip-tailed Lizard	(Cnemidophorus tigris mendus)
Pacific Blue-bellied Lizard	(Sceloporus occidentalis occidentalis)
Long-nosed Snake	(Rhinocheilus lecontei)
Western Yellow-bellied Racer	(Coluben constrictor vetustus)
Pacific Rattlesnake	(Crotalus oreganus)

* Grinnell and Camp, 1917; Storer, 1925.

Flowing water is the staff of life to arid California and has given the state an ever changing landscape. (Figures 9, 9A) Ancestral streams possibly flowed at greater capacities and caused great amounts of erosion--as witnessed by the fact the alluvial fans in the Tulare Basin are in some places more than 2,000 feet deep.

On the east side in the lower valley, three rivers, the Stanislaus, Merced and Tuolumne, head at high altitudes in the mountains, and serve as outlets for melting snows. Interlaced with these large streams are smaller rivers and creeks, the Calaveras, Chowchilla and Fresno Rivers are three, that head lower on the western flank of the Sierra Nevada and siphon surface waters off the mountain side. This has lessened the need for the larger streams to carry water, for the interceding streams effectively reduce their drainage areas. The Tuolumne River historically carried more water than any San Joaquin Valley stream on the western flank of the Sierra Nevada. Yet this waterway, like the Stanislaus and Merced, has not altered the landscape to the degree streams have in the upper valley.

The Tulare Basin main streams, the Kings, Kaweah and Kern, head in the high mountains. They are not so interspersed with smaller streams, and because they fall so precipitously, they dug deep canyons at their upper levels. Their rising alluvial fans blunted their flows as they reached for the valley trough, and in so doing caused the rivers to continually bifurcate until their

fans became indented from the criss-crossing of multitudinous sloughs. The alluvial fans acted as sinks, and as much as forty percent of the natural flow of these streams sank into the earth before reaching the valley trough. During periods of normal rainfall, a portion of the Kings River flowed into Fresno Slough, hence south into Tulare Lake. The remaining waters debouched into Fresno Slough to the north before they reached the San Joaquin River. The Kern River at an early date indirectly fed the thirty-one square mile Kern Lake through sloughs. Two good sized streams, White River and Poso Creek, dumped their waters into sinks. As a result, a seasonal wetlands area, varying annually in size, and called locally "Visalia swamp", formed in the area of Visalia.

Tulare Basin streams were well known for their erratic flows, and they annually changed the character of both land and waterscapes in the basin. During periods of high water, estimated flows of 60,000 sec/ft pulsed down the Kings River. (Latta, 1937B) At high water this stream ran freely into Tulare Lake and into the San Joaquin River via Fresno Slough. Much of the Kings River fan became a temporary wetlands. Waters from the White and Tule Rivers and Poso Creek may have reached Tulare Lake during torrential stream flows. At high water, Kern River fed wetlands to the south and west of Bakersfield and Kern Lake. The latter lake emptied into Buena Vista Lake. Buena Vista Lake flowed into Tulare Lake via Buena Vista Slough. Tulare Lake, when its surface waters reached 210 feet above sea level,

debouched over the transectional barrier lobe and into Fresno Slough, hence into the San Joaquin River.

By June, snowpacks in the Sierra Nevada had diminished, and stream flows declined. During the summer and fall months, flows in the Kings River may have been reduced to 150 cu ft/sec. (U.S. Congress, 1900) At this time "Visalia Swamp" lost its marshy character, and a thick crust of alkali covered extensive areas over the Kaweah and Kings River fans. Any waters flowing in the Tule and White Rivers disappeared into sinks. Water did not pass between the three southern lakes, and Tulare Lake ceased debouching into the San Joaquin River.

Nothing better illustrates the changing nature of the waterscape in the Tulare Basin than the fluctuations in size of Tulare Lake. (Figure 10) Pedro Fages spoke in glowing terms of the immense lakes that covered the upper valley in 1772. (Bolton, 1931) But even during the Spanish period, Tulare Lake became so shallow at times that a tule-covered sandridge divided the lake east and west, beginning at the city of Alpaugh and extending west to the foothills of the Coast Range. The Spanish called the divided lake Tache (the upper lake) and Tan Tache (the lower lake). They named the sandridge Las Calaveras, or the Skulls. (Latta, 1937B)

The facts seem to be, in brief, that in years of average rainfall and snowpack the level of Tulare Lake's surface was about 204 feet above sea level, or six feet below the crest of the transectional lobe to the north. At 204 feet above sea level the lake was at a maximum twenty-five feet deep, and covered an

area of approximately 300 square miles. It is suspected, if not verified, that water levels in the lake declined dramatically or even dried up during "El año del hambre" (the year of the famine) in 1805, in 1809-1810, 1816-1817, 1820-1821, 1828-1830, 1840-1841, in 1845-1846, and many times thereafter. Low water may have occurred as well, throughout the period 1820-1832. In dry years Tan Tache, the lower lake, became a marsh or dried up, and the water levels in Tache declined. During successive years of drought, Tache water levels fell further, often becoming one foot deep or less except on its western edge. As lake levels fell, the water became rank. At such times it was not uncommon for the Indian residents to wade one-half mile or more into the lake to retrieve potable water. In especially dry years the Yokuts who resided at or near Tache Lake were forced to migrate to the east, into the Kaweah River fan, to find drinking water. (Latta, 1937C)

Flooding of the lake occurred as well. The flood of 1849-1850 has been noted as having been severe. But the greatest flood recorded in the state's early history occurred in the winter and spring of 1861-1862.

In November and December 1861, large quantities of snow fell in the Sierra Nevada. In December, statewide temperatures rose an average of eleven percent above normal, and warm rain began to fall. Modest flooding began on December 9, and was subsequently fed by twenty-five and one-half inches of rain that fell between December 23, 1861, and January 24, 1862. The first heavy stream flows from the mountains appeared the day following Christmas, 1861, and continued into spring. In January tides rose twelve

feet above their normal summer low, and five feet above the highest ever recorded. At that time, water stood two feet high in the area bordering Suisun Bay on the north, the Sacramento River above Collin's Landing stood four feet deep, and at Rio Vista eight feet deep. (California, Surveyor General, 1862)

On January 11, 1862, the water level at Millerton on the San Joaquin River rose to twenty-six feet above low water; at Herndon, sixteen feet above low water. (Ibid.) Grunsky (1898) reports that 300 billion cubic feet or 6.9 million acre feet of water flowed into the Tulare Lake Basin at this time. The surface of the lake rose to 220 feet above sea level, expanded in size from about 300 square miles to 800 square miles, and lake waters thirteen feet deep flowed over the transectional lobe. Overflow waters expanded over lands on the San Joaquin River's west side, and ran four feet deep over an area so large it could not be estimated; although it was thought to have reached a width of from five to twenty miles in Stanislaus County. The Stanislaus and Tuolumne Rivers became a mile wide due to overflow. The flooding waters ate away tall bluffs, and ripped away all riparian vegetation, including oak trees five to ten feet in diameter. In some areas, river bottoms increased from 200 to 1,500 feet wide. From five to twenty-five feet of bottom lands were swept down the rivers, and silt deposits six inches to four feet deep settled over a wide area of nearby overflow lands. Dr. L.M. Booth, of Branche's Ferry on the Stanislaus River, reported that nine-tenths of the crops, buildings, and livestock by the hundreds were lost during this flood. Overflow waters

also destroyed significant amounts of standing timber on the Stanislaus, Tuolumne and Merced Rivers. (California, Surveyor General, 1862)

The Kern, Kaweah, and Kings Rivers changed courses during the flood of 1861-1862. The Kern River cut a new channel to the north, which left Kern Lake without a perennial source of water. Changes in the courses of the Kern and Kaweah Rivers resulted in the natural conversion of very large sections of once well defined wetland areas. Flood waters on the Kings River widened Cole Slough to such an extent that the main stream of the river thereafter flowed northwest, rather than southwest and into Tulare Lake. Further deposits of sediments subsequently collected at the mouth of the south branch of Kings River, and water flowing from the Kings River into Tulare Lake were virtually cut off except during periods of overflow. (California, Department of Engineering, 1918)

Later flood waters seldom reached the levels that appeared in the flood of 1861-1862, although reports suggest that floods occurring at least once each decade following the 1860's nearly reached this benchmark. To about 1880, average levels in Tulare Lake remained at or slightly above 200 feet above sea level. They subsequently dropped, and never reached the 200 foot level again. The final great overflow from Tulare Lake into the San Joaquin River in the Nineteenth Century apparently occurred in 1878. (Latta, 1937B)

LAND CLASSIFICATION

Climatic factors, water action, earth movements, chemical and biological actions modified the earth's crust over the past thirty-five million years to create soils of varying types within the San Joaquin Valley. Early soil scientists (U.S. Department of Agriculture, 1918, 1919, 1921) identified ninety-four soil and soil sub-types present in the valley which they grouped under four provinces: the residual soils, or those derived in place by the disintegration and weathering of consolidated rocks; old valley and coastal-plains soils, or modified old and unconsolidated water-lain materials; recent alluvial soils, materials of recent disposition that have undergone no important modifications; and wind-laid soils which owe their presence to wind action. Broadly speaking, the residual soils occupy the higher, rougher elevations in the foothills, and the old valley-filling and coastal-plain soils lie intermittently between the residual soils and the recent alluvial soils that cover wide areas on the valley floor.

With this information at hand, other experts collected additional data from U.S. Geological Survey topographical maps and related material, then classified lands in the valley in terms of their agricultural potential. Figure 11 provides a general illustration of the classified agricultural lands identified by California authorities in 1930. Definitions of the various classes of lands are as follows: Class 1 lands represented areas where soil texture, alkali accumulations and

topography did not limit crop yield or discourage irrigation. They could produce high crop yields at reasonable costs for preparation, and could carry the costs for irrigation. Class 2 lands, flawed because of the presence of hardpan, roughness, alkali or other factors, could on the average carry the costs required for irrigation. Class 3 lands could not justify the costs of irrigation provided by regulated water supplies due to the presence of high concentrations of alkali, or the costs involved in land preparation or land leveling. Class 4 lands were considered of such poor quality that they could not produce cultivated crops, but were suited for use as flooded pasture. Class 5 lands were heavily alkaloid, shallow in depth, rough, underlain with hardpan, or steep, and were not considered cultivatable. (California, Department of Public Works, 1931) The blank or white areas indicated on the enclosed illustration represent alkali lands that observers believed would never be agriculturally productive.

Within the upper valley, class 1 lands covered an area of 2,821,600 acres, and class 2 lands totaled 1,241,300 acres. Fresno County had the greatest area of class 1 lands, 1,110,100 acres. Kings County had the least, 394,600 acres. Class 1 lands in the lower valley totaled less than one million acres (942,100), or about fifteen percent less than the same class of lands in Fresno County. A total of 653,888 acres were identified as class 2 lands in the lower valley. (Ibid.) The lands identified as class 1 and class 2 in the upper valley exceeded the identical class of lands in the lower valley by 255 percent.

Importantly, water supply data reveals that natural annual stream flows in the lower valley exceeded those in the upper valley by more than 200 percent. (Ibid.) The stage was thereby set for future problems when, after the 1870's, irrigators in the upper valley expanded canal and ditch enterprises, and water demands exceeded the available supplies of surface water.

INDIAN INFLUENCES

Indian groups began their migration from Asia to California several thousand years ago. Two families, the Yokuts and the Mivoks and their subgroups, settled in the San Joaquin Basin: the Yokuts in the plains or grasslands, the Mivok groups in the foothills east of the San Joaquin River axis and in the lower valley. (Figure 12) The Mivoks established village sites along the San Joaquin River and its principal tributaries. Like Indian groups to the north, they became fishers of salmon, which supplemented their regular dietary fare of seeds and acorns. At its apex the population density within the area reached ten to twelve persons per square mile. (Levy, 1978)

The Yokuts spread out over a larger area and had a population density of two to three persons per square mile. (Wallace, 1978A, 1978B) The Yokuts, like their counterparts to the north and east, chose streamside locations for settlement, and a sizable population lived on lakeside sites at Buena Vista and Tulare Lakes. Since oak trees in this region were scarce,

grass seeds, the edible parts of tule plants, fresh water fish, waterfowl and some mammal flesh made up the greater parts of the Yokut diet. Following Spanish settlement they also became eaters of horseflesh. (Ibid.)

Anthropologists theorize that the California Indians did not adopt a formalized system of cultivated agriculture because "Agriculture was neither adaptive nor necessary for an attractive existence...". (Lewis, 1973) A few Yokuts in the upper valley may have planted small areas in pumpkins and vegetables with seeds taken from the missions. And there is evidence that Miwok groups in the north raised some wheat prior to 1850. But areas cultivated by the Indians never became so extensive that they seriously impacted either the flora or fauna within the San Joaquin Basin. (Baumhoff, 1978)

Evidence that California Indians burned vegetation to encourage the propagation of seeds and for purposes of hunting are recorded in traveler's reports, and have been substantiated in the Twentieth Century through studies by experts. (Lewis, 1973; Heizer and Elsasser, 1980) But no evidence unveiled during the preparation of this report reveals that the Yokuts intentionally, systematically, and periodically set fire to the grasslands within the San Joaquin Valley. The question of whether they did so or not is largely academic. But it has its practical side as well, for if the Indians did not burn over the grasslands, we must presume that other forces were at work that converted the pristine flora to the geoflora complex that emerged following European settlement.

The fact that the Yokut Indians controlled and traded large numbers of livestock, particularly cattle, has not been fully recognized. According to W.P.V. Smith (1932), Indians within the Tulare Basin had before 1819 become mounted and could compete competently against Spanish cavalrymen. Moreover, the Indians began to breed cattle stolen from the missions by the same date, and held regular fairs at Tulare Lake where livestock were traded and sold. By 1824, Smith testifies, the Indians controlled large herds of cattle. Later, following the secularization of the missions, ex-neophytes led raids upon Spanish coastal settlements and stole horses and cattle which added large amounts of stock to their already sizable herds. The raids became so intense that regular cattle drives were organized that led to Tulare Lake, and by the middle of the 1830's the lake "...became a terminal such as Dodge City later became for the cattle drives from the Great Plains." By 1837 livestock trading grew to such an extent that various American adventurers established a rendezvous at Tulare Lake and began driving stolen cattle to the East by way of Walker's Pass and New Mexico.

Livestock trading by the Yokuts led to important changes within the upper valley. The large numbers of animals that are thought to have grazed within the area reduced, perhaps even eliminated, much of the native herbaceous plant cover. This provided the opportunity for the growth of the deviant plant community of half-shrubs or subshrubs that were present near Buena Vista Lake; the seeds of which were in part imported on the livestock or in their waste. Livestock could very well have

contaminated local water supplies. And they certainly scarred and impacted the soft soils in and around the lakes.

A lasting and perhaps more serious result was that early livestock trading activities introduced American cattlemen to the Tulare Lake Basin. They recognized the area as a valuable source for food and water, and in later years cattlemen drove thousands of head of livestock into the area. This caused great stresses on the resource base and lead to confrontations between "interlopers" and settlers within the region.

SPANISH AND MEXICAN PERIODS

Of the several impacts made by the Spanish and Mexican peoples three stand out: they first explored the San Joaquin Valley, thereby providing future travelers and settlers with knowledge of the valley's resources(5); by importing livestock and plants they helped change the landscape in the basins; and during the Mexican period the government granted large areas of land to individuals, which at a later date influenced landholding patterns in the valley. (Figures 13A, 13B)

Pedro Fages made the first recorded entry into the valley in 1773. Juan Crespi and others followed in 1776 and thereafter, until well into the Nineteenth Century. Most of these explorers offered glowing opinions of the resources of the region, saying the area offered both good grass and water for livestock. However, the padres in the coastal missions were too preoccupied

in the early decades with other matters, and did not concern themselves with valley settlement. When, after 1820, the padres decided to reconnoiter the area and locate sites for missions, they discovered there was a shortage of wood for construction purposes, and soils near potential mission sites were impregnated with alkali. The missionaries considered these burdens to settlement too difficult to overcome, and they abandoned the idea of mission building in the valley. Settlement in the San Joaquin Valley did not subsequently begin until the 1840's.

Although Spanish settlement did not constitute a land use in the valley, indelible imprints were left on the landscape by the livestock Spaniards imported into California.

Environmental conditions in Alta California provided an ideal base for the pastoral economy that prevailed during the Spanish and Mexican periods. The first cattle imports totaled less than 200 head. Later introductions may have increased the total livestock numbers brought into the area to a few thousand cattle and a fewer number of horses. During the decades that followed, populations of both cattle and horses multiplied greatly due to uncontrolled breeding, and by the turn of the Nineteenth Century several hundred thousand head of cattle and horses grazed throughout Alta California's coastal valleys. Ultimately, some animals escaped from the coast region and entered the San Joaquin Valley where they ran wild.

For forty years or more following the Spanish entry into California, herds of cattle located on the coast provided the hides and tallow needed by the settlers for home use and export.

Feral animals roaming in the San Joaquin Valley were, therefore, largely ignored and left to multiply. But by 1815 changes occurred that placed restrictions on the growth of feral animal populations. In that year, or shortly before that time, Spanish vaqueros began holding annual rodeos on the eastern flank of the Coast Range of Mountains. Livestock were corralled, branded, and some cattle may have been killed at this time for their hides and tallow. At about the same time the Yokut Indians became adept horsemen and began their own rodeos. Reductions in feral livestock numbers followed. A final check on the free-roaming stock resulted when changing weather conditions decimated livestock herds in the San Joaquin Valley. After 1800, droughts became particularly severe in the valley, and drought conditions occasionally extended over long periods of time. Flora, normally drought tolerant but stressed by the continued grazing by feral animals, succumbed under the added pressures induced by droughts. Without feed, and with shortages of water prevailing throughout the valley, feral livestock died by the tens of thousands. After 1864, about the only feral stock that were seen in the valley were strays that had somehow avoided both man and the checks imposed by nature.

The presence of feral animals in large numbers within the San Joaquin Valley resulted in fundamental changes in the landscape. It has been recognized, for example, that localized overgrazing occurred around watercourses (Brewer, 1949), and it appears that in some areas severe damage was done to grasslands located adjacent to streams and to riparian vegetation.

Destruction due to overgrazing throughout the grasslands area does not seem probable though, for livestock require copious amounts of water and will graze close to water sources.

The stressing of the native flora in wetlands and riparian sites by overgrazing provided the ideal environment for the establishment of foreign plants introduced by livestock on their hides and in their waste. By the early 1830's, as a consequence of seed introduction by animals (and perhaps by migratory wildlife), much of the pristine flora had disappeared, and in its place stood weeds represented by such introduced species as Red Brome (Bromus rubens), Downy Chess (Bromus tectorum), False Foxtail Fescue (Festuca myuros), European Foxtail (Festuca bromoides), Foxtail Fescu (Festuca megalura), Hare Barley (Hordeum leporinum), Glaucous Barley (Hordeum glaucum), Nitgrass (Gastridium ventricosum), Purple Falsebrome (Brachypodium distachyon), and Silver Hairgrass (Aira caryophyella). Additional species known to have been imported by the Spanish for their forage value and which found their way into the valley included Wild Oats (Avena fatua), Slender Wild Oats (Avena barbata), Annual Ryegrass (Lolium multiflorum), and, perhaps, Soft Chess (Bromus mollis), Ripgut (Bromus diandrus), Bur Clover (Medicago polymorpha), and the Filarees (Erodium spp.). (Crampton, 1974) For the next generation these plants prospered. It was recorded, for example, that the wild oats to the east of the San Joaquin River grew so high that tufts could be tied over the back of a horse.

Several of the above species proved to be of great value for livestock forage. The widespread growth of introduced flora also impacted wildlife habitat; although it remains unclear how, or to what degree, changes occurred.

AMERICAN PERIOD, TO 1870

Physical conditions prevailing throughout the arid west often confused immigrants migrating from the humid regions. Most travelers crossing the vast desert region considered the area a wasteland due to the lack of rainfall. Husbandmen could scarcely believe crops could be grown on these lands. And, livestockmen who had grazed their herds on lush prairie grasses viewed the sparsely vegetated land with dismay. What the Forty-Niners and later westernbound travelers did not appreciate was that a new era in the history of agricultural development in the United States was on the horizon: a time when irrigated agriculture would be introduced and be used to convert large areas of semi-arid and arid lands into productive farms.

Federal land policies, enacted to accommodate settlement in the humid region, did not meet the needs for development within the arid west. In the Nineteenth Century, Congress passed legislation that encouraged the taking up of public lands in 160 acre plots. But the physical realities associated with arid land settlement did not mirror humid area conditions, and early western travelers immediately recognized that ambitious,

hardworking individuals settling on small farms could not independently conquer the desert. The foremost requirement for settlement was to quickly capture scarce water supplies. To accomplish this further required the taking up of land in large tracts, or in strategically located tracts that encompassed the soughtafter water supplies. Widespread development also depended upon infusions of large amounts of capital contributed by investors who could, for better or for worse, best exploit the natural resource base by running large herds of cattle over sparsely vegetated range lands, or introduce heavily capitalized irrigation enterprises. But large amounts of venture capital did not flow to areas where land disposal was governed by faulty laws. When Congress did not adequately respond to the problems associated with arid land settlement, avoidance of laws, misrepresentations and fraud became prevalent. Few early western immigrants considered these matters though. All eyes were turned to the gold fields, and the Forty-Niners quivered in anticipation.

As the miners crowded into California and the Sierra Nevada looking for gold, several thousand individuals found their way south and located in the mountain counties of Calaveras and Tuolumne. (Figures 14A-14B) This area consequently became the center of population in the San Joaquin Valley, and remained so for nearly two decades. During this era small farms appeared whose sole output went to the farmer and to feed hungry miners.

While gold seekers washed down thousands of tons of soil in the Calaveras River and disrupted stream flows with their

makeshift dams, Stockton, due to its strategic location, began its growth as the San Joaquin Valley's major trade center. Stockton's access to both the mines and the city of San Francisco also encouraged the growth of a local agricultural sector supported by immigrants who understood that more income could be realized by cultivating the soil and growing vegetables than by standing in icy water panning for gold for two dollars a day. Grain production soon followed, for flour brought high prices and livestock needed feed. By 1860 San Joaquin County growers helped fill these needs by annually producing one-half million bushels of wheat, one-half million bushels of barley, and by mowing native grasses that weighed fourteen thousand tons. (U.S. Census, 1864) By 1870, annual production of wheat increased 600 percent and barley and hay production tripled. (U.S. Census, 1872) And, although San Joaquin County did not at this time become the center of livestock production, it held a firm second place position among all valley counties.

Stanislaus County realized but modest population growth before 1870. (Figures 15A-15C) The county acted as a buffer as agriculture enterprises spread to the south from San Joaquin County. Nevertheless, with a population of less than 6,500 residents (U.S. Census, 1872A), county officials could boast in 1870 that local farmers produced 1.65 million bushels of wheat, and two-thirds of a million bushels of barley. This placed the county in second place among all counties in the valley.

Merced County did not reach full bloom until after the turn of the Twentieth Century. Interest in livestock production and

agriculture thrived, nonetheless, and by 1870 Merced County became the valley's leading cattle center, and 45,000 sheep grazed over the county's range lands.

It is not apparent that serious restrictions, including land holding patterns, hampered the growth of the agricultural sector in the lower San Joaquin Valley. The three counties where agricultural production became important, San Joaquin, Stanislaus and Merced, had comparatively easy access to outside markets, farmers could acquire lands at costs that permitted the production of crops with lower market values, production did not require expensive improvements, and the topography, climate and soils supported the growth and expansion of extensively operated grain farms. As a result, large farm operations (from 500-1,000 acres in size) multiplied between 1860 and 1870. In San Joaquin County, for example, farms of 1,000 acres or more increased fifty-one percent, and farms 500-1,000 acres in size increased 2,069 percent. Stanislaus and Merced Counties experienced similar patterns in the growth of large farms. (U.S. Census, 1864, 1872A)

Farmers in the above counties not only brought their properties into production at an early date, but tilled the majority of the cultivatable lands included in their farms. Again, in San Joaquin County, class 1 and 2 agricultural lands totaled 546,100 acres. Total land in farms equaled 430,471 acres. Of the latter amount, farmers improved 428,061 acres on which they grew 305,020 acres of grains.[6] (U.S. Census, 1872A) To put this in another perspective: by 1870 seventy-nine percent

of class 1 and 2 agricultural lands had been taken up in farms; seventy-eight percent of the class 1 and 2 agricultural lands had been improved; and fifty-six percent of class 1 and 2 lands produced grain crops. These statistics indicate that by 1870 only twenty-one percent of quality agricultural lands remained open for the production of crops in San Joaquin County. Stanislaus and Merced Counties experienced similar patterns in land use.

The agricultural belt in the lower San Joaquin Valley had by 1870 been largely defined, and early land use patterns established. Future growth, although not eliminated, was inhibited due to the lack of better agricultural lands. Without a change in cropping patterns and the introduction of high-value crops, farm size would remain comparatively large. In the face of these odds, settlement pressed ahead and development continued. As a result, before 1880, farmers extended their operations beyond the belt of prime agricultural lands and had placed 32,000 acres of lessor quality lands (class 3 and 4) in farms. (U.S. Census, 1883)

A rapid taking up of land in the lower San Joaquin Valley effectively eliminated speculative opportunities for investors and developers. Further expansion could only take place in the large and open space within the upper valley, and west of the San Joaquin River: the West Side. But, uncertainties governed the future development of these areas. Arid land conditions prevailed in the upper valley and on the west side. Irrigation would be required to convert these areas into a rich agricultural

region. Yet, land remained available at low cost, and entrepreneurs presumed this would become the future home of thousands of families. As if drawn by a magnet, land speculators, developers and owners of large livestock operations moved south to take up large tracts of land and capture the area's water supplies.

Environmental factors, the relative isolation of the region, and the fact that no transportation facilities were available determined the course of agricultural development in the upper valley from 1850 to the early 1870's. During this period, the open range remained an attraction and livestock operations prevailed.

By the early 1860's, the thousands of head of livestock driven to California during and following the gold rush filled the range in the northern Central Valley. Stockmen then moved south to buy up lands and begin large livestock operations within the San Joaquin Valley. Heavier American stock, with a greater capacity for food, soon displaced the lightweight Spanish cattle throughout the valley. Early census reports do not reveal the numbers of livestock grazing on range lands, only the number of cattle on farms. It is impossible to state, therefore, either the numbers of head of livestock grazing on the range or the condition of the grasslands. However, it has been reported that by 1860 three million or more horned cattle grazed on California grasslands. (U.S. Census, 1864) A portion of this massive livestock population certainly was present in the San Joaquin Valley. Yet other evidence suggests that herds in the upper

valley were not so large that significant pressures were placed either on the grasslands or water supplies. (Ludeke, 1980) But a series of events beginning in the 1860's changed this setting.

Range lands in the upper valley had not fully recovered from the devastating flood of 1861-1862 before the great drought came in 1863-1864. Little rain fell during the fall and winter of 1863-1864, and snowpacks did not accumulate as customary. During the spring and early summer a blistering hot sun covered the valley, and the thin vegetative cover shriveled and died. Untended livestock then began to perish for lack of grass and water. During the summer of 1864 as many as 200,000 to one million animals died throughout California, and decaying carcasses carpeted the landscape. (Bancroft, 1890)

This drought led to the deaths of the majority of feral livestock that ranged within the San Joaquin Valley. It also threatened the destruction of herds grazing in the coastal valleys. As a result, alert livestockmen drove their cattle from the coast and from Southern California to the upper San Joaquin Valley, and into the Delta region to feed and water. From 40,000 to 60,000 additional head of cattle filed into the Tulare Lake region to graze on sparse vegetation, and to consume scarce local water supplies.(7) They marred and compacted the moist soils in and around the lakes with their hooves. Interloping cattlemen allowed their animals to roam freely, and they trespassed into private pastures and settlers fields. Disputes arose. And when many outside cattlemen did not withdraw their herds following the drought, tempers continued to flare. By early 1871 both local

livestockmen and settlers agreed that some action must be taken to restrict grazing and protect the property of settlers. The two interest groups then began lobbying the state legislature to enact a measure to alleviate their mutual problem. After some hesitation the legislature did act, and in 1874 passed the No Fence Law.[8]

Basically, the No Fence Law of 1874 reversed an act passed in 1850 that required settlers to fence their lands to prevent intrusions by roaming cattle. The new law did not, conversely, require livestockmen to fence their lands or confine their livestock to protect settlers lands. However it did state that trespassing animals could be captured, and owners of roaming livestock had to pay property damages if they wished to recover the seized animal or animals. (Ludeke, 1980) The No Fence Law affected land use practices in a fundamental way, since it forbade trespass without penalty. Nonresident livestockmen chose not to face such sanctions, and generally withdrew their herds. Resident livestockmen were inspired to fence their lands.

In 1870 the population in the upper San Joaquin Valley centered in Fresno and Tulare Counties, and totaled under 14,000 people. Land in farms totaled 473,113 acres, although improved land in farms equaled but 68,630 acres. Fresno County had 240 farms, Tulare County 377 farms and Kern County 86 farms. Grains grew on 15,152 acres. Unreliable census statistics indicate that the three counties produced 5,043 head of cattle and 245,280 head of sheep. Land in farms comprised 12.5 percent of all class 1

and 2 lands in the upper valley. Improved lands covered only 0.4 percent of class 1 and 2 lands. (U.S. Census, 1872)

AN ASSESSMENT

By 1870 the San Joaquin Valley had 4,390 farms, and agriculturalists grew 395,611 acres of wheat, 143,645 acres of barley and 43,082 acres were mown for hay. Acreages devoted to wheat equaled 2.1 percent of total land area within the grasslands-foothill area, and acreage planted to barley equaled 0.8 percent of the same area. Hay was mown on 0.2 percent of the grasslands-foothill area. Land in farms totaled 2,137,533 acres, of which 1,435,605 acres were improved and 701,928 acres unimproved. These three totals represented, respectively, 11.3 percent, 7.6 percent and 3.7 percent of the valley lands. (U.S. Census, 1872A, 1883) Lands devoted to other crops are not recorded in the census. The census also did not report numbers of range cattle, so cattle enumerations are meaningless. Sheep numbers appear more nearly correct at 573,927, for sheep, unlike cattle, did not range unattended and could be counted.

A miniscule amount of land may have been irrigated at this time, but grains and hay were dry-farmed. Native grasses comprised the majority of mown hay, although green-cut wheat may have been mown for hay by some producers.

Statistics are not available for acres of woodlands on farms prior to 1870. The 1870 census (Figures 16A-16D) reported a

total of 54,382 acres of woodlands on farms of which the majority were located in the counties boarding the Sierra Nevada Mountains. (U.S. Census, 1872) It is interesting to note in this connection that San Joaquin County did not report any woodlands on farms in 1870. Since early travelers frequently referred to the great stands of oaks and other trees that existed in San Joaquin County, this lack of census data indicates that: 1) settlers did not enclose woodlands (including riparian vegetation) on farms; 2) landowners removed all trees from their properties prior to 1870; or 3) that the census contained an error. It seems probable that the latter is true.(9)

AGRICULTURAL DEVELOPMENT, 1870-1930

Irrigated agriculture in the San Joaquin Valley may have first been attempted on small farms in the mountain counties when growers diverted flows from miners ditches onto their vegetable crops. Such practices appear to have been short-lived though, for mining lasted but a short time, and public utility companies often acquired mining ditches and flumes following their abandonment by the miners.

Early attempts at irrigation on the valley floor had inconspicuous beginnings too. Some settlers plowed shallow furrows to use as ditches, and where practical they plugged sloughs with brush dams to trap water. Irrigation did not become extensive by any means, for bringing first water to kitchen

gardens at an early date was beyond the financial means of many settlers. Cooperative enterprises did arise prior to 1870, formed by neighboring farmers, but it appears that irrigators often failed to maintain their ditches, and waterways became clogged with debris and overgrown with tules and other water-loving plants.

Land speculators with grandiose schemes for the conversion of wetlands and for irrigation enterprises led the parade into the upper valley in the 1850's and 1860's. One man received a grant of state lands on condition that he reclaim overflowed lands in the upper valley. He was not successful, but during the flood of 1861-1862 the Kern River changed its course and converted over 6,000 acres of wetlands for the fortunate fellow. One group proposed a canal between Tulare Lake and the San Joaquin River to enhance inland navigation. This idea never bore fruit because the transectional lobe crossing the valley became a barrier. Nevertheless, at least three bills passed by the California legislature awarded this group tens of thousands of acres of land in the Tulare Lake region. (California, Surveyor General, 1862) John Bensley began in 1869 to build a canal from Fresno Slough, northwest and across the West Side. Bensley's project failed, only to be taken up by a well financed group from San Francisco who decided to build an inland shipping canal and massive irrigation system. Their plans called for the construction of a 500 mile long canal that began at Tulare Lake and terminated at Redding. As it wound its way through the valley, the proposed canal touched upon virtually every stream of

consequence flowing down the western flank of the Sierra Nevada Mountains. This plan failed too, partly because several sponsors of the project filed for bankruptcy during the nationwide economic depression of 1872-1873. (Browne, 1872) Miller and Lux, a minor partner in the firm known as the San Joaquin and Kings River Canal and Irrigation Company, purchased the company's assets at a nominal cost and extended the canal across the West Side. The San Joaquin and Kings River Canal system is now familiarly called the Main and Outside Canals.

Irrigation developments in Southern California became the model for enterprises constructed throughout the arid west. Privately financed, fast paced construction, and comparatively efficient, Southern California projects demonstrated that an important avenue to success lay in entrepreneurs' ability to attract farmers to the land through colony settlement. The system had worked well in Southern California for more than a decade prior to 1870, and this fact did not escape the attention of later developers. Neither did investors ignore the fact that low cost public lands were still available in the upper valley, that claims could still be filed for water rights on major upper valley streams, and that the Central Pacific Railroad was posed and eager to begin construction of a line south, along the valley floor. Inspired entrepreneurs such as James Ben Ali Haggin, William B. Carr, William S. Chapman and Issac Freidlander had by the early 1870's made their move to the south. And within a few years Haggin's holdings in Kern County totaled 300,000 acres. Chapman owned 160,000 acres in the same county. These holdings,

in turn, were dwarfed by the 1.6 million acres controlled by the Southern Pacific Railroad in Kern County. (Gates, 1978) Fresno and Tulare counties contained large land holdings as well. (Figures 17A-17C)

Land being held in such large tracts could have, but did not necessarily discourage settlement within the upper valley. As a rule, people who owned large tracts, such as Haggin and Chapman, made major capital outlays to improve their lands. Some, like Haggin (the Kern County Land Company), heavily invested in irrigation enterprises, subdivided their holdings and offered incentives to prospective settlers, like low-interest, long-term financing. They either channeled water to the settlers property or arranged for water delivery. And they encouraged the introduction of such high-value crops as alfalfa, citrus, deciduous fruits and grapes. (U.S. Department of Interior, 1878; Thickens, 1946)

Individuals, cooperative farmers groups, mutual water companies and, after 1887 and the passage of the Wright Act, irrigation districts contributed to the growth of irrigated agriculture as well. It was with some pride then that Californians could read in Frederick H. Newell's report in 1890 (U.S. Census, 1894) that farmers in Fresno County were irrigating 105,665 acres of land, and that growers in Tulare County, living on 1,287 farms, irrigated 168,455 acres. Irrigated farms in the San Joaquin Valley comprised somewhat more than twenty-five percent of all irrigated farms in the state, but valley producers

irrigated 50.24 percent of all lands in the state then irrigated. (Figures 18A-18E)

The introduction of irrigation drastically altered land use patterns in the upper valley. Population size increased 481 percent between 1870 and 1890. (U.S. Census, 1895) Farms of all sizes multiplied from 703 in 1870 to 5,273 in 1890. Total land in farms expanded from 473,113 acres to 3,014,220 acres, and improved land in farms increased from 68,630 to 1,679,267 acres. (U.S. Census, 1895A) (Figures 19A-19H) Moreover, unspecified amounts of land had been leveled, clean cultivated and prepared for the planting of intensively grown crops.

Within a twenty year period (1870-1890) the number of acres irrigated in the Tulare Basin increased from near zero to almost one-half million acres: a phenomenal growth when considered in terms of the conditions under which irrigated agriculture expanded. When cast in another light it seems less significant. Total irrigated acres in the Tulare Basin in 1890 comprised but eleven percent of all class 1 and 2 lands in the basin, they totaled less than fifty percent of class 1 lands in Fresno County, and lands placed under ditch remained but a fraction (9.8 percent) of all lands in the basin. These statistics do not, of course, reveal the location of irrigated lands, which partly determined their impact on wildlife and its habitat.

Wheat prices remained at a level that encouraged California farmers to continue to grow the crop in great quantities to 1890. (Figures 20A-20B) So, as lands opened up and development proceeded in the upper valley, producers moved into the area and

began dry farming grain and cultivating grain for hay. (Figures 21A-21B; 22A-22B) Production levels were not high, averaging 7.7 bushels per acre for wheat. And growers quickly learned that a good crop could be produced but once in every three or four years. Nonetheless, in 1890, upper valley growers produced 5.5 million bushels of wheat on about three-quarters of a million acres of land.

A rapid spread in irrigated agriculture did not greatly influence the operations of the range cattle and sheep industries (Figures 23A-23C), for ample amounts of land remained undeveloped. Livestockmen let their beef cattle range over enclosed grasslands untended, and fed them alfalfa for fattening. The dairy industry, like much of the agricultural sector, experienced vigorous growth after the Southern Pacific Railroad pushed through the valley in the mid 1870's. Milch cow numbers grew through this period, just as the acreages of alfalfa on which they fed multiplied. Numbers of sheep rose rapidly, and although production of mutton and wool reached its peak in the 1870's, great flocks remained in the valley throughout the period under review. (Figures 24A-24C)

Checks on the expansion of the agricultural industry in the San Joaquin Valley appeared periodically throughout its initial stages in growth. Dry land farming had been pushed to its upper limits by the 1880's. Expansion of irrigation enterprises was curtailed prior to the 1890's, checked mostly by the lack of surface water supplies in the upper valley. Fruit did not market well in the 1890's, which put a check on plantings. Irrigated

wheat produced in British India, and the rise in shipments of grain by other foreign competition, reduced the need for California wheat at Liverpool, California's chief overseas market. Local conditions were compounded when the agricultural sector, nationwide, suffered from the economic downturn associated with the depression that grasped the nation in the 1890's. As demand and prices for wheat fell, California growers shifted land use practices to include more high value crops.

The maturation of California's agricultural sector began at the turn of the Twentieth Century. Farmers found relief in the formation and spread of farmers cooperative production and marketing organizations. The Southern Pacific Railroad contributed to the growth of the citrus industry by waging advertising campaigns in the Midwest that promoted oranges. In the Sacramento Valley, farmers began to grow rice on the adobe soils that previously grew wheat. Row and tree crops became more important in the lower San Joaquin Valley. Simultaneously, a surging interest in cotton production occurred within the upper San Joaquin Valley, because producers found that cotton, like wheat, could be grown on lands moderately affected by alkali.

Tradeoffs affecting both land and water resources accompanied the introduction of new crops on California farms. In the Sacramento Valley, rice growers siphoned water supplies from streams and flooded areas that in former years had been dry lands. As the intensity of production increased, practices such as land leveling became widespread, and increasingly sophisticated machinery permitted deeper cultivation and cleaner

harvests. Similar changes took place in the San Joaquin Valley with increases in the production of fruits, vegetable crops, citrus, vines and cotton. (Figures 25A-25F) The expanding agricultural sector in the latter area provoked increased demands for water for irrigation. But surface water supplies were by this time largely secured by water rights. Irrigators began then to intensively tap the vast aquifers laying beneath the floor of the upper San Joaquin Valley.

After 1900 the numbers of water wells being brought on line multiplied by the thousands. In 1902 farms irrigated from wells in the San Joaquin Valley totaled 495, and the total acreage irrigated from wells was 17,591. (U.S. Census, 1904) By 1910 farmers pumped from 3,798 wells and irrigated 70,718 acres with well water. It came as no surprise that growers in San Joaquin County used 1,618 of the wells and irrigated 8,642 acres, for they had long before 1910 irrigated with water drawn from wells used to drain high water tables. (U.S. Census, 1922) In 1920 the number of wells being used in the valley totaled 11,223, and by 1930 wells located only in the upper valley had capacities totaling 32,571 gallons per minute from flowing (artesian) wells, and 9,253,643 gallons per minute from pumped wells.[(10)] (U.S. Census, 1922, 1932A) Indiscriminate pumping of water from underground aquifers in great quantities did, of course, have expected consequences. Producers overdrafted subsurface water supplies, and the water table dropped: precipitously in some areas. (Figure 26)

Increases in nearly every part of the agricultural sector in the San Joaquin Valley closely paralleled the growth in the number of wells being brought on line after 1910. By 1930 the number of farms in the valley grew to 39,952, and comprised about 29.5 percent of all farms in California. Land in valley farms expanded from 7.8 million acres in 1910 to 22.4 million acres in 1930, and improved land in farms increased 225 percent, to 8.7 million acres. (U.S. Census, 1932B) In every county except Calaveras and Mariposa, the number of irrigated farms increased. Merced County lead the way with a hefty 45.2 percent increase in the number of irrigated farms. (U.S. Census, 1932A) Due to changing land use patterns, and for other reasons, some counties did experience a decrease in the number of acres irrigated. For example, irrigated lands in Fresno County dropped 2.5 percent, and Kern County experienced a 19.4 percent drop. Irrigated lands in the mountain counties declined as well; severely in some cases.

The following statistics provide an overview of the changes that occurred in the San Joaquin Valley by 1930. In 1929, the total population in the valley, exclusive of the Delta region, was 561,851: 291,887 lived in urban areas, 149,569 were rural non-farm folk, and 192,395 people lived on farms. (U.S. Census, 1932C) Urban populations totaled 2.30 times the rural population. Population density averaged 17.75 persons per square mile: about one-third more than when the Mivok Indians occupied the lower valley two centuries earlier.

In 1929 transportation had made major advances, and many types of agricultural commodities were shipped via truck rather than by rail. Manufacturing and food processing plants were established. But, neither roads nor the growing small towns and urban areas appear at this time to have greatly infringed upon the valley's agricultural lands.

There were, by 1930, 39,932 farms with total land in farms of 8,699,950 acres (13,593.68 square miles), or about forty-three percent of all lands in the valley. Unimproved lands in farms totaled 5,048,321 acres, improved lands equaled 3,651,629 acres. Improved agricultural lands therefore covered 5,706 square miles or eighteen percent of all valley lands. Cropped lands, as opposed to improved lands, totaled approximately 2,750,500 acres of which irrigated lands made up seventy-nine percent, or 2,159,100 acres.

Surveys of cropping patterns show that irrigated citrus groves, deciduous fruit and olive orchards, vineyards and truck crops totaled 865,850 acres, or 40.1 percent of all irrigated land. Irrigated grains totaled 11.4 percent of irrigated lands; alfalfa, 18.2 percent; field crops, 8.3 percent; cotton, 12.9 percent; irrigated pasture, 2.5 percent; and unclassified, 3.0 percent. Dry farm crops included 1,700 acres of deciduous fruit and olive orchards; 6,000 acres of vineyards; 378,000 acres of grains; 1,300 acres in alfalfa; 7,800 acres in field crops; and 100 acres in truck crops. Clean cultivated crops, that normally required land leveling, frequent cultivation, generally used furrow irrigation, and required frequent applications of water,

comprised 63.9 percent of all land in crops in the San Joaquin Valley. Crop production in the upper valley covered 1,201,800 irrigated acres; in the lower valley, 763,000 acres. Leading irrigated crops in the upper valley consisted of grapes, cotton, alfalfa, field crops, fruits and olives in order of importance. In the lower valley alfalfa, grains, grapes and deciduous fruits became the leading irrigated crops.

In summary: upper valley producers had a total of 3,938,400 acres of class 1 and 2 agricultural lands; they improved 1,696,026 acres or 43.1 percent and irrigated approximately 71.6 percent of the improved lands. The lower valley contained 1,736,000 acres of class 1 and 2 lands. Improved lands in farms totaled 1,955,603 acres, or more than one-quarter million acres more than those designated as class 1 and 2. Irrigated lands comprised 56.8 percent of class 1 and 2 lands, or 50.4 percent of all improved lands in the lower valley. (Figures 27, 28)

Cropping patterns and land use are two indices that may be used in measuring agriculture's impact on wildlife and its habitat. Other considerations involve means of production and practices followed by producers as they husbanded land and grew livestock.

When wheat dominated the market place, speculative fever penetrated throughout the agricultural sector in California, and no portion of the state's farming community was better known for speculative conduct than San Joaquin Valley grain growers. In their efforts to gain a market share, producers followed such slovenly habits as broadcasting seed over ill-prepared fields;

after the first year's harvest, many farmers did not plant a second crop but harvested volunteer crops; and most growers harvested grain slothfully until the later decades of the century when the use of the combined harvester became common. Early settlers sometimes interplanted cash crops while trees and vines matured, but this practice did not become common among producers of row crops such as corn. Crop rotation was rarely seen on grain farms, and only at the end of the century and thereafter did grain farmers practice fallowing.

Technological improvements in the manufacturing of farm machinery, the introduction of new types of machinery, falling grain prices, rising market demands for California farm produce other than grain, and the increasing sophistication and application of the sciences to production guided the state's agricultural sector into the Twentieth Century and into the nation's market place. As a result, larger acreages of land were leveled, clean cultivated and planted to crops such as cotton that had no value in terms of wildlife habitat. By 1930, farmers showed increasing interest in the application of fertilizers, and had embraced fully the use of poisons to eradicate mammals and avifauna that threatened crop production.

Cultivated lands made up but a portion of all land in farms, and attention should be drawn to land use practices on unimproved lands within the agricultural sector. In 1930 unimproved land (refer again to footnote 6 for a definition of improved land) on all farms within the San Joaquin Valley totaled slightly over five million acres (7,888 square miles). Unimproved land on

farms therefore comprised fifty-eight percent of all land on farms, and twenty-five percent of all valley lands. Total land on farms (improved and unimproved) thereby totaled forty-three percent of all valley lands. The remainder was taken up in small part by urban and industrial uses, while a much larger portion remained open space.

It is unclear at this time what the character of the unimproved lands in farms was before 1930; i.e., whether they were cultivatable lands lying idle for want of water for irrigation; if the lands were stony, alkali, hilly, forested, mountainous, and not cultivatable, etc. Whatever their character, it is apparent that after 1900 unimproved lands on farms could be better utilized as range for livestock than in the Nineteenth Century. Three reasons can be advanced to support this hypothesis: 1) Advances in technology, in the manufacture of pumps and extension of electric power, permitted the drilling of water wells in areas where livestock could not have grazed at an early date; 2) Livestockmen had by 1930 become increasingly aware of the dangers accompanying overgrazing, and tended to allocate numbers of livestock pastured according to the carrying capacity of the land; and 3) The increasing production of alfalfa and use of other supplemental feeds in the Twentieth Century tended to reduce the use of the range or unimproved lands.

If the foregoing statements are sound, it seems possible that more unimproved land on farms was put to use in the Twentieth Century, but that the intensity of land use decreased. It can be further reasoned that an expansion of livestock grazing

over lands that had heretofore not been available for this purpose would lead to further destruction of wildlife habitat. The damage to wildlife habitat might not be so severe as formerly, however, if the acres per animal unit month were reduced. Future analysis will reveal the correctness of these assumptions.

WATERSCAPE

Certain benefits, such as an influx of federal funds, accrue when waterways are designated navigable streams, and from its formation the California legislature periodically petitioned Congress to have rivers and creeks in the state designated as navigable waterways. Real concern over the state's river systems did not arise, however, until hydraulic mining practices washed soils down streams in the north Central Valley. The office of the California State Engineer was in part created because of this, and William H. Hall became the first state engineer in the 1870's. Hall's interests extended beyond the flooding of north state rivers. He had a particular interest in the benefits of irrigation, and during the 1870's and 1880's he investigated river systems and published detailed reports on advancements made in irrigation worldwide and in Southern California. The engineer took measurements on various streams within the San Joaquin Valley, and his published reports of gaugings are the first knowledge that we have relating to stream flows in this area.

For various reasons Hall's measurements, taken between 1879 and 1883, are of historical interest only. Further measurements were not taken and published until the 1890's, when the U.S. Geological Survey took readings on selected streams within the valley. Then, in 1903, the Survey began a cooperative effort with the State, and by 1929 eighty-nine gauging stations reported stream flow measurements on a regular basis.

Beginning in the early 1920's state authorities paid increasing attention to stream flows, urged on by the continuing need for irrigation water in the upper San Joaquin Valley, and by the knowledge that underground aquifers in the valley were rapidly being drained by increased pumping of water. One result of the investigations was that specialists compiled tables and graphs representing the unimpaired run-off of San Joaquin Valley streams.[(11)] Figure 29 generally illustrates state estimates of unimpaired run-off for the period 1889-1890 to 1924-1929. Particular attention should be given to this illustration, for it demonstrates that a change took place in stream flows in the San Joaquin Valley that are not often considered in discussions of water supplies and water use, particularly in the upper valley.

Changing rainfall patterns caused a reduction in stream flows during the referred to period. Rainfall records begun in about 1873 at Fire Station No. 2 in the city of Merced indicate that, between first recording and 1905, levels of precipitation dropped approximately 300 percent. Rainfall then increased to 1930, although the pattern followed a meandering course. Also, precipitation levels after 1905 never reached more than about

eighty percent of that of the first reading taken in 1873. (Kahrl, 1979)

Because precipitation levels dropped, we can speculate with some degree of confidence that stream flows also declined between 1873 and 1889-1890. And they continued to fall as depicted in Figure 29. For example, mean seasonal run-off of the Kern River (1889-1890 and 1924-1929 compared) fell a fraction over fifty percent. The Tule River fell from 163,000 acre feet annually to 77,600 acre feet, or 47.6 percent. And the Kings River fell from 4,620,000 to 226,000 acre feet. San Joaquin River flows dropped a substantial amount; from 4,620,000 to 1,333,000 acre feet annually. (California, Department of Public Works, 1931) Comparisons between other statistical years would, of course, be different. The point is that unimpaired stream flows in all rivers throughout the valley dramatically declined during the period when large irrigation enterprises started, and continued when rapid growth in irrigation took place. Dwindling surface water supplies were further reduced by new enterprises coming on line. Areas that might have been irrigated when canal enterprises first began, therefore, might at some later date not be serviced, or received less water for irrigation.

To gain better control of the valley's surface water supplies, individuals, cooperative groups, then state sanctioned organizations such as water storage districts, municipal improvement districts and irrigation districts built dams, levees and drain lines to capture or redirect stream flows. By 1930, 269 diverting dams, eighty-five storage dams and 1,419 reservoirs

of various capacities existed on streams and in various large sloughs. (Figure 30)

Landowners also tried to control floods. In the Kings River-Tulare Lake areas, organized reclamation districts constructed levees surrounding an aggregated area of 235,000 acres. (Ibid.) Neither individuals nor organized groups have ever gained full control of flood waters in the upper valley, however.(12)

Declines in precipitation, the reductions in unimpaired stream flows, and the capture of surface waters for irrigation and municipal purposes ultimately led to the disappearance of the confined waters in the valley's trough. At some unrecorded date Summit Lake, a small lake located a few miles north of Tulare Lake, disappeared. Kern Lake, without a feeder after the flood of 1862, began drying up. By the year 1878 water in the lake had become so putrid and salty that the aquatic biota died. (U.S. Census, 1884) Kern Lake subsequently dried up. Buena Vista Lake, Kern Lake's northern neighbor, served as a reservoir for the Miller and Lux properties for a number of years, but it ultimately dried up too. Tulare Lake, as previously mentioned, had such erratic behavior that it seems quite impossible to say precisely when it "disappeared".(13)

Some wetlands and swampy or marshy areas in the valley also disappeared as farm drainage operations expanded. A history of farm land drainage in California has yet to be written. Census data do reveal, however, that in California during the years 1920 and 1930 over 5,000 farms had drainage operations, and about

800,000 acres were provided with drainage. Within the San Joaquin Valley, 1,078 farms had drainage. The majority, 951, were located in the lower valley. Lands provided with drainage in the upper valley counties of Fresno, Kern and Tulare totaled 8,877 acres. In the lower valley like lands totaled 158,410 acres, of which San Joaquin County singly accounted for about 115,000 acres. (U.S. Census 1922, 1932) Figures 31A and 31B illustrate the organized enterprises operating in California's Central Valley in 1920 and 1930. Not included in this report are data enumerating acres of farm lands drained by operators not associated with organized enterprises.

The quality of waters in California's streams interested W.E. Hilgard of the University of California in the 1880's. At that time he reported the rivers on the west flank of the Sierra Nevada had good water quality, with the exception of Kern River which contained some salts. Tulare Lake was unfit for use for potable water or for irrigation when applied to lands that contained alkali. (U.S. Census, 1884) Irrigators, ignoring Hilgard's warning, nonetheless partitioned off the lake with levees, used the water for irrigation, and directed return waters back into the lake through hoses that passed over the levees.

State authorities, too, were concerned about water quality, particularly in the San Joaquin River. The San Joaquin and Kings River Canal and Irrigation Company constructed the Mendota weir to divert San Joaquin River waters south into Fresno Slough in the early 1870's. Thereafter, all waters flowing into the river between the slough and the mouth of the Merced River at low water

were return waters from upland irrigation enterprises. In 1906, in 1908 and again during the period 1930-1932, water quality tests were taken on the various valley streams by the Water Resources Branch of the U.S. Geological Survey. Survey chemists uniformly classified the waters as "good", and stated that both stream waters and the return waters in the San Joaquin River were chemically satisfactory to serve all needs of municipalities, industry and irrigators. (California, Department of Public Works, 1931)

AN ASSESSMENT

Between 1870 and 1930 California went through a period of adolescence. The Gold Rush had passed. New economic opportunities arose, such as the development of an agriculture sector, that offered promises of stability and a basis for future economic expansion. Wealth that had been amassed during the early period were, following 1870, diverted to investments that fostered this growth. Californians, however, could not shed the speculative fever that lingered following the Gold Rush, thus new enterprises were often embossed with the stigma of a "get rich scheme". Within the agricultural sector, speculative fever translated into efforts to capitalize on the state's wealth of natural resources, and the production of crops that required a minimum of investment in both capital and labor. The early years

in the growth of the agricultural sector was, as a result, devoted to growing grain and producing livestock.

But market conditions and increases in the prices of farmland eventually encouraged speculators to move on to other enterprises. They were often replaced by farmers who introduced new cropping patterns and exercised greater care in husbanding the land. Land leveling, deeper plowing, clean cultivation, disking, harrowing and more efficient means of harvesting became increasingly important. Increases in settlement, the taking up of land over larger areas, the establishment of smaller more intensively cultivated farms, and the introduction of irrigated agriculture began processes that altered both the land and waterscapes in the valley to a greater degree than did the earlier practices of grazing and grain growing.

Traditionally, frontier settlers located on river bottom lands to take advantage of good soils, wood and water supplies. Immigrants moving into the San Joaquin Valley followed this pattern, but were discouraged from developing intensively operated farms on river bottom lands because streams were often bordered by poor soils, high bluffs on the larger rivers blocked access to flowing waters, and all bottom lands remained subject to periodic and devastating floods. Wood for fuel remained in continued demand until oil became available and the fuel of choice, and some posts for fences were required. But timber was scarce throughout the valley and was not of a quality that encouraged its use. As a result, the demands placed upon woodlands and riparian vegetation as a whole seemed moderate, and

its destruction likewise appears to have been modest. Moreover, riparian wildlife habitat removed by settlers seems to have been more than offset by the introduction and expansion of irrigated agriculture.

Nor did the conversion of wetlands to farm land appear to have been particularly destructive to standing timber. No data are available prior to 1919, but of the counties in the San Joaquin Valley reporting drainage enterprises in the 1920 and 1930 census, only one, San Joaquin County, indicated that woodland was cleared and cultivated (179 acres) following wetlands conversion. No counties reported the conversion to farmland of timber or cutover lands. (U.S. Census, 1932)

The spread of intensively cultivated farms scarred the land in the San Joaquin Valley over increasingly large areas, and the maturing of irrigated agriculture profoundly changed the valley's waterscape. At the same time changes were taking place in the composition of the geoflora.

Forces acting to encourage plant successions after 1833 included the transporting of seeds by migratory wildlife, the introduction of non-native seeds by American and Mexican livestock, the importation and distribution of seeds through settlement and the practice of cultivated agriculture, and the intentional efforts of agronomists at the University of California who introduced over 100 species of flora, and attempted to establish these plants within the Central Valley grasslands community.

As stated earlier in this report, researchers think that the first plant succession took place in the San Joaquin Valley grasslands by 1833. The second community of plants thrived, but they too were succeeded in part by other hardy perennials, probably by 1878. Filaree, introduced during the second or perhaps the third period of plant introduction, became dominant over areas once occupied by wild oats and wild mustard. Associated with filaree were mouse barley (Hordeum leporinum), bromegrass (Bromus, spp.), nitgrass (Gastridium ventricosum), and foxtail fescue. Yet another succession appeared in the 1880's, characterized by mouse barley, mediterranean barley (Hordeum hystrix), red brome (Bromus rebens), silver hairgrass (Aira caryophyella), tarweed (Hemizonia), turkey mullein (Cremocarpus setigerus) and similar species. (Burcham, 1957) The addition of these flora to the valley did not, of course, lead to the disappearance of native plants; the latter thrived in some areas. But by the 1880's irreversible changes to the geoflora had occurred, and the presence of native flora diminished still further in the following decades as land uses became more intensive and encompassed larger areas throughout the valley.

LAND USES AND WILDLIFE

Agricultural land use practices in vogue before 1930 in the San Joaquin Valley influenced wildlife by modifying or destroying habitat, but they do not appear to have directly lead to the

deaths of wildlife. As agriculture expanded and ever increasing amounts of surface waters were diverted for irrigation, some species of wildlife abandoned local sites, while other species adapted to the new environments and thrived. Because we do not know all species of wildlife that were extant in California's pristine environment, their habitat type and their areal extent, and because it is impossible to determine at this time land uses on each parcel of land in the Lower Sonoran Life Zone in the San Joaquin Valley, we cannot track on a case by case basis how agricultural land use practices affected most wildlife. In the paragraphs that follow, therefore, we note changing patterns in agricultural land use over time, and suggest the impacts they had on selected wildlife species. A statement will also be made on farmers use of poisons to reduce certain wildlife populations.

Although grazing by feral animals altered wildlife habitat, it has yet to be determined how individual species of mammals and avifauna were impacted. The Pronghorn Antelope, biologically well suited to arid grassland environments (Figure 32), possibly fared better than the Tule Elk (Figure 33), for feral livestock directly competed with the elk for both food (riparian vegetation) and water. Raptors and predator mammals undoubtedly benefited by the presence of feral stock for the reason that rodent populations tend to increase over areas grazed by these animals. Avifauna that nested at riparian sites, among the grasses and hydrophytes that grew in and around lakes, sloughs and streams, lost habitat due to grazing livestock, and local populations may have been reduced as the birds migrated to

nesting sites in other areas. Burrowing animals such as the San Joaquin Kit Fox possibly colonized areas on the periphery or outside the grasslands area normally grazed by feral animals (Figure 34), and may not have been adversely effected by the presence of these livestock.

Assessments of the impacts on wildlife by practices associated with cultivated agriculture must be described in comparative terms. For example, cultivation of the soils for the extensive planting of grains disturbed and often destroyed habitat for some species of mammals and avifauna. Damages inflicted to habitat during the early years, say prior to 1880, were comparatively less than in later years because the first farmers plowed shallow, rarely leveled land, harvested by hand or with crude machinery, and frequently did nothing following the first year's planting other than harvest volunteer crops. Some mammals, such as the ground squirrel, overcame these adversities and thrived in the new environment. Other rodents and fauna undoubtedly migrated to undeveloped areas. If rodent populations declined, there would also have occurred a general migration from cultivated areas of flesh eating mammals and birds. Grain production supported some types of waterfowl and land birds by providing an important source of food. Night-feeding waterfowl became so numerous and so destructive in grain fields, in fact, that farmers hired hunters to kill the waterfowl, and some producers scattered poison grains to reduce bird numbers. (Alta California, 1878) Because bird populations were so high at that time, hunters could not effectively protect grain fields. The

effects on wildlife from spreading poisons were devastating, as will be demonstrated later in this study.

Once again trade-offs appeared as settlers proceeded to partition lakes, divert stream flows and drain wetlands. The available supplies in water bodies such as Tulare Lake was always subject to change, and secure habitat for migratory waterfowl and marsh nesting birds such as the Tricolor Blackbird could never be assured. The presence of even moderately large bodies of water attracted flocks of avifauna nonetheless, and it is suspected that avian cholera ran rampant among waterfowl during periods of low water.

Partitioning of both Tulare and Buena Vista Lakes by levees, and their cultivation by landowners guaranteed a more or less continuous reduction in the sizes of these lakes after 1880. Avifauna that required large bodies of water for habitat were most affected by the reduced water availability. As could be expected, local populations declined, including, but not limited to, the following species: American Eared Grebe (Colymbus nigricollis californicus), Western Grebe (Aechmophorus occidentalis), White Pelican (Pelecanus erythrorhynchos), Farrallon Double-crested Cormorant (Phalacrocorax auritus albociliatus), California Great Blue Heron (Ardea herodias), American Black-crowned Night Heron (Nycticorax mycticorax hoactli), White-faced Glossy Ibis (Plegadis guarauna), Whistling Swan (Cyghus columbianus) and Trumpeter Swan (Cygnus buccinator). (Grinnell and Miller, 1944)

The efforts of man to capture and retain waters for irrigation, and the permanence of these supplies, offset somewhat the amounts of water lost when lake sizes dwindled. Certain waterfowl readily adapted to the new conditions and may have benefited from irrigated agriculture. Examples are, the Great Blue Heron (*Ardea nerodias nyperonça*), Common Mallard (*Anas platyrhynchos*), Baldplate (*Nareca americana*), North American Black Gallinule (*Gallinula choropus cachinnans*), and North American Coot (*Fulica americana americana*). Adaptation did not mean, however, that reductions in population sizes of certain species of avifauna did not occur. Widespread depletion in numbers of Canvas-back Ducks (*Nyroca valisihera*), Redhead Ducks (*Nyroca americana*) and the species listed in the previous paragraph took place locally and statewide. (*Ibid*.) It has not yet been ascertained to what degree the agricultural sector was responsible for declines in avifauna populations statewide, and how much responsibility for declines can be assigned to the activities of hunters and to other causes.

Land leveling, clean cultivation of lands and furrow irrigation used in the production of citrus, fruit and truck crops and cotton virtually eliminated wildlife habitat. Of the mammals, rabbits survived well in this environment, and beaver families thrived in the irrigated areas. The numbers of quail increased manyfold. Other land birds migrated from riparian sites to take up homes in the more secure environment of irrigated fields, and both the numbers and specie types of land

birds multiplied on irrigated lands according to available studies. (Kennedy, 1914; Hurtz, 1980)

San Joaquin Valley fishes fared less well. Irrigated agriculture encouraged the building of dams, weirs and levees that obstructed fish runs. Pumping of water from streams had ill-effects on fish too, but it is not apparent how much damage pumping caused. A study completed by the state Division of Fish and Wildlife in the spring and summer of 1929 found that pumping by one district on the Sacramento River did little damage by sucking fish into pumps. (Phillips, 1931) A similar conclusion may not be reached regarding the San Joaquin River where lower stream flows prevailed. Thirty-five pumping plants operated between the mouth of the Merced River and Stockton, and no study refutes the fact that these pumps did not wreck great havoc on fish populations during periods of low water. (Figure 35)

There is within the composite picture of agricultural land use a particularly disquieting feature; i.e., the use of poisons to control certain animals that farmers considered pests. Ground squirrels especially came under attack, for they caused damage to crops that amounted to hundreds of thousands of dollars annually.

Efforts to control ground squirrels in the Nineteenth Century remained casual. Farmers, encouraged by both state and federal governments, independently scattered poison baits or gassed the creatures with carbon bisulphide. No regulations governed either where these poisons were applied or in what amounts. It is hard to judge, therefore, how greatly squirrel

numbers were reduced, or how greatly applications of poisons effected other species of wildlife.[14]

By 1909 S.E. Piper of the Bureau of Biological Survey, U.S. Department of Agriculture, developed a formula that utilized strychnine coated whole barley for bait. Laboratory tests revealed that the poisoned barley, when properly treated with strychnine, would not harm avifauna, and over the years this bait became widely used within the agricultural sector.

Neither the state nor federal authorities did follow-up studies to determine how greatly strychnine coated whole barley impacted wildlife. The threat it posed only came to light when in 1932 T.T. McCabe reported in Condor (McCabe, 1932) that he observed an experimental kill of Tricolor Blackbirds (*Agelaius tricolor*) that proved conclusively that poisoned bait did widespread damage to avifauna. McCabe described the test area, located near Marysville, as being nearly free of a variety of birdlife due to the fact that most birds had been frightened away by a vast rookery of Tricolor Blackbirds inhabiting the area. The author describes the rookery as immense in size: "The number of birds which crossed a single very limited sight-line past one corner of the swamp had, during one period of observation, been about 170 a minute."

Personnel from the Biological Survey conducted the experiment by spreading strychnine laced grain at the site. McCabe reported that the results were "appalling". Great numbers of Tricolors died at once. Seventeen hundred birds were gathered from within a very small radius and tossed in a pile. "Later,

the surface of the shallow water beneath the willows became an almost solid floor of floating bodies...". McCabe later visited the site and reported that the poisoned grain continued to be an effective killer of blackbirds. Decayed birds were observed hanging from trees and from their nests in the rushes. Great numbers of deaths occurred among the newly hatched birds in the nests, and unhatched eggs by the thousands were observed. The author estimated that this one kill reduced the blackbird rookery by 30,000 birds.

McCabe's purpose in publishing these observations was to discourage the further killing of Tricolor Blackbirds. He had read in a local paper (Tribune, 1931) that the Board of Supervisors of Stanislaus County authorized S.E. Piper of the Biological Survey to destroy blackbirds, horned larks and linnets that were feeding on crops within the county. Piper planned to distribute poisoned bait, and McCabe hoped to discourage this practice by arousing public sentiment against its use. The chances that McCabe would succeed in his one-man effort were slim. During the ten year period 1920-1930, over fourteen million pounds of prepared poisoned grains, and over six million pounds of carbon bisulphide were distributed throughout the state's agricultural sector. (Linsdale, 1931) And, it appeared, farmers in 1932 were not hesitant to use poisons, regardless of prices paid in the destruction of wildlife.

A new and more poisonous compound, sulphate of thallium, introduced in 1928, was added to the list of poisons used by growers. This deadly substance, which has physical and chemical

properties similar to lead, was introduced for rodent control in Germany about 1920. The U.S. Department of Agriculture tested sulphate of thallium for effectiveness in 1925, and made plans for its distribution in California in 1926. During 1928, 7.7 million acres of land in the state were treated for ground squirrels. Sulphate of thallium comprised 602,728 pounds of the 2.0 million pounds of bait used. (Ibid.) According to one authority, this amount of poison, could kill 176 million pounds of living matter. (Shaw, 1932)

Follow-through investigations by concerned researchers illustrated how threatening sulphate of thallium was to wildlife. Paul A. Shaw (1932), for example, visited Yosemite Lake, picked up sixty dead or dying geese along one mile of lakefront, and returned them to a laboratory for analysis. Tests revealed that thirty-two of the geese had been killed by sulphate of thallium.

In an earlier study, Jean M. Linsdale (1931) showed that thallium killed more than geese. Reports from sixteen counties where thallium was spread for ground squirrel control indicated that avifauna, rabbits, deer, turkeys, cattle, Gray Foxes, goats, a wildcat, skunks and a variety of other animals were killed. One person reported that the entire badger population in Madera County was eradicated because they ate dead squirrels that had eaten poisoned bait. Another reporter stated that some pasture lands had been made unfit for grazing, and could not be used until, in six months, rains appeared to wash poisoned baits from the land. No one at this time speculated on the damage to fish that would result as the poisons flowed into the rivers, hence

into the Delta and San Francisco Bay. Linsdale did not attribute all deaths to thallium poisoning, but did suggest that sulphate of thallium contributed significantly to the destruction of wildlife.

Statistics on wildlife kills resulting from the commercial fumigation of citrus groves using cyanide gas resulted in fewer wildlife deaths than when farmers used poisoned baits. An inspection (True, 1931) of citrus groves in the Dinuba and Visalia areas in 1931 indicated, nonetheless, that avifauna, rabbits and even a tree toad died from cyanide poisoning. The investigator's estimate was that one bird died for each 100 trees planted, or about one bird per acre suffered from cyanide poisoning.

The efforts of individual farmers, livestockmen, and both state and federal authorities led to the destruction of large numbers of mammals and avifauna through applications of poison baits. The only comparable threat to these species resulted from the activities of hunters.

HUNTING AND WILDLIFE

The abundance of wildlife in California invited their exploitation. Early hunters had easy access to sea otter's coastal habitat, and otters could easily be captured. A great fur trading market resulted that began in the 1820's and continued into the 1840's. Shipments of skins of land based fur-

bearing mammals became a part of the fur trade prior to the gold rush, but it is virtually impossible to determine the types or numbers of skins which entered the market, for bills of lading did not commonly distinguish among types of furs forwarded. Antelope skins probably made up a large part of the shipments, for it is known that the Spanish killed antelope for tallow and skins. Annual shipments of skins of all land based mammals, other than beaver, seldom exceeded 4,000 skins.

Fur-bearing mammals occupying the Lower Sonoran Life Zone in the San Joaquin Valley lacked richness in varieties of species, and, with exceptions, did not have population sizes equal to those present in other areas in California. Trappers nonetheless found it profitable to hunt beaver, and following Jedediah Smith's entry into the valley in 1826, American and Hudson Bay Company trappers worked the area until beaver populations were too exhausted to make trapping profitable. A decline in beaver numbers became apparent in the middle 1830's. The early trade ended in about 1846 when the Hudson Bay Company abandoned its outpost at French Camp in the lower San Joaquin Valley.

As shipping increased, so did the demand for furs in foreign markets. A rapidly expanding population in California also demanded food and clothing. Market hunters responded, and in the second half of the Nineteenth Century hunting and trapping operations expanded to include nearly all species of fur-bearing mammals, waterfowl and some non-game birds. Within a few years some species such as the White Swan, whose skin was in demand in retail furrier markets, became scarce. (San Francisco Chronicle,

1877) Within the Lower Sonoran Life Zone in the San Joaquin Valley, mink, Gray Fox, beaver, weasel and Kit Fox numbers declined across the board. (Grinnell, Dixon, and Linsdale, 1937) Some species became extinct: examples are the California Grizzly (Urus spp.), Long-eared Kit Fox (Vulpes macrotis macrotis), Mexican Jaguar (Felis onca hernandesii), Oregon Bison (Bison bison oregonus), and the Lava Beds Bighorn (Ovis canadensis californiana). (Grinnell, 1933)

Other species were reduced to a point they almost became extinct. Prior to the American occupation of California, large herds of California Wapiti Elk (Cervus nannodes) and Pronghorn Antelope (Antilocapra americana) fed on valley grasslands during the winter and spring. All parties traveling into the valley freely killed these animals for food, and market hunters took hides. By the mid 1850's both species suffered population declines. Hunting continued, however. In 1864 the Alta California (1864) reported that a hunting party had returned from the San Joaquin Valley with a catch of ten antelope. Market hunters, too, remained active. H.C. Banta stated that his partner, Bob Dikeman, shot the last elk cow and calf on the east side, lower San Joaquin Valley near the Mokelumne River, in the early 1860's. (Evermann, 1915) John Paine, another market hunter, supposedly killed the last Tule Elk in Suisun Marsh in about 1868. (Ibid.) By 1870 but a few head of elk foraged in the valley. The story has often been repeated that the Miller and Lux firm saved the elk from extinction by enclosing the remaining few head on their Buttonwillow Ranch.

The Pronghorn Antelope met much the same fate as the Tule Elk. Bryant (1915) states that in the early 1850's antelope meat was the most common to be found in the San Francisco market. By the early 1880's herds that previously numbered in the thousands within the San Joaquin Valley had been reduced to 200-300 animals. In 1898 observers counted thirty-two antelope; in 1909, 138; in the Spring of 1914, 28; and in October, 1914, seven sightings were reported statewide. (Ibid.)

Market hunters also provided nineteenth century residents in San Francisco and Stockton with ample supplies of bear, rabbit, deer, quail and pigeons. (Cronise, 1870) But no meats were more abundant on butcher's racks than fish and waterfowl.

Reports on inland fisheries relate that ambitious fishermen blocked the channel of the Sacramento River with huge nets that stretched from bank to bank. They realized huge catches by this method, and by 1880 a large salmon canning industry operated in Sacramento. In that year producers packed 60,000 cases or 2,880,000 pounds of salmon. In 1881 production increased to 200,000 cases or 9.6 million pounds. (Bancroft, 1890) Moreover, commercial salmon catches remained high throughout the period 1870-1910, with annual production varying between two and ten million pounds. (Skinner, 1958)

Tulare Lake also supported a small inland fishing industry. Accounts are sketchy regarding developments, but local lore supports the idea that aquatic species were abundant in the lake. The story is told of one man with a 100 foot sein that caught eighty to one hundred terrapin at a time. The season catch from

Tulare Lake was estimated to be from 180 to 300 dozen terrapin. A second story tells of the fisherman who had a horsepowered windlass pulling a 2,000 foot sein. In a four to five hour period this man and his crew caught as much as three tons of a variety of fish, one ton or more of which could be marketed. (Latta, 1937D)

The state legislature periodically passed laws to protect inland fisheries and to enhance sport fishing. Early acts prohibited gill netting, limited the length of nets and restricted fishing seasons. But fishermen breached the laws and catches remained high. Finally the legislature created the State Fish Commission in 1870 to bring order to the fishing industry. This Commission became very active in enforcing laws, salmon hatcheries were established, and new species of fish were introduced into California waters. The commissioners also enforced such regulations as one that required all owners of dams, weirs and other obstructions to stream flows to build fish ladders. Game regulation became a part of the Commission's responsibilities in the 1880's. And in the early 1900's the state created the Division of Fish and Game.

Avifauna, particularly waterfowl, suffered great declines in numbers following settlement. The American Common Egret (Casmerodius albus egretta) became rare prior to 1900, due mostly to demands in the feather trade. Neither the Western Turkey Vulture (Cathartes aura teter) nor the California Condor (Gymnogyps californianus) had economic value, but hunters practiced their marksmanship on these birds with serious results.

The American Osprey (_Pandion haliaetus carolinensis_), California Roadrunner (_Geococcyx californiancus_) and Suisun Long-billed Marsh Wren (_Telmatodytes palustris aestuarinus_) suffered similar fates and for many of the same reasons.

The virtual disappearance of the California Least Vireo (a riparian dweller) in the Lower Sonoran Life Zone presents an interesting case. Nineteenth Century naturalists did not sight the vireo over a long period, and some assumed it had become extinct due to the birds being driven from its natural habitat by settlement, grazing and the cultivation of soils. These assumptions were proven incorrect at a later date when naturalists discovered the vireo had changed life zones, and was nesting in the Transition Life Zone, above the Upper Sonoran Zone. Grinnell and Miller (1944) attribute this change in habitat by the vireo to have resulted, not directly from farm land development or hunting, but from the infusion into the valley of a large number of cowbirds. Cowbirds, it appears, heavily parasitized the nesting sites of the vireo, and the latter took flight into a different life zone.

Local newspapers frequently stated that waterfowl could not be found anywhere that were greater in quantity or of better quality than those in California. (_San Francisco Chronicle_, 1878A) Accounts of kills substantiated the fact that waterfowl migrated to the state in great numbers, and were easy targets for hunters. The _San Francisco Chronicle_ (_Ibid._) reported, for instance, that three hunters shot 242 ducks in one morning. Another article said that hunters at Tulare Lake bagged 150

snipe, 27 geese and 200 ducks in two days of shooting. (San Francisco Chronicle, 1878B) One man shot twenty-five pelicans with one shot. (San Francisco Chronicle, 1878C) And W.E. Houghton of Kern County claimed he killed nineteen geese with one shot, thirty mallard ducks with one shot, and twenty-six geese with another blast of his gun. (San Francisco Chronicle, 1879)

Because of their rapid growth, both San Francisco and Stockton became great markets for waterfowl, and every variety could be seen for sale. Each day wagon loads of ducks and geese arrived from throughout the Central Valley. Estimated daily shipments into the San Francisco market equaled from fifty to one hundred fifty dozen waterfowl. For each duck delivered, market hunters received about ten cents. Thus, to stay economically solvent, market hunters stated they felt obligated to fell from 100-200 ducks each day. (unidentified newspaper article, dated December 31, 1876, Bancroft Scraps, Bancroft Library) A market for waterfowl eggs existed as well, and gathering eggs became an avocation for residents living near nesting sites. It is not uncommon, reported the Chronicle (San Francisco Chronicle, 1878A), for one consignment of 200 dozen eggs to come into the San Francisco marketplace at any time.

Thousands of waterfowl fell before the guns of sportsmen too.(15) Hunting became so popular that the Southern Pacific Railroad added cars to existing trains, and on weekends and holidays ran special trains to the Delta region to accommodate hunting parties.(16) Beginning in the 1870's, duck clubs became popular in California. And by 1911 some hunters used airplanes

to kill waterfowl on the grounds of the Bolsa Chica Club in Orange County. (Forest and Stream, 1910)

In 1850 waterfowl were so tame that a person could walk within six feet of a bird before it took flight. By 1852 waterfowl became gunshy in some areas. And by 1892 sportsmen throughout the state recognized that waterfowl populations had markedly decreased, and supplies of birds in some areas had become scarce. But almost another decade passed before citizens interested in protective legislation took actions that led in 1901 to the enactment of laws that placed bag limits on waterfowl. The first state act provided for a limit of fifty birds a day per hunter. (Welch, 1931) The establishment by the state of bag limits on waterfowl encouraged recovery in their populations. But for reasons that are yet to be explained, sizable increases in bird numbers did not take place. For, as Grinnell and Miller (1944) later reported, flocks of waterfowl had not materially increased at mid-century above the low levels reached in the 1890's.

CONCLUSIONS

Land use practices in the San Joaquin Valley between 1769 and 1930 significantly influenced population sizes and mixtures of mammals, aquatic biota and avifauna that inhabited the Lower Sonoran Life Zone. The foremost problem associated with all types of land use was the destruction of wildlife habitat that

accompanied human occupancy and the conversion of land for agricultural purposes. And as the intensity of land uses increased, so did the destruction of habitat multiply.

The alteration or destruction of habitat, however, did not necessarily lead either to permanent population declines of various species (except locally), or to the extinction of known forms of wildlife. Evidence to support this hypothesis rests on the following: 1) The Lower Sonoran Life Zone extended beyond the boundaries of the San Joaquin Valley, and unless this expanded area had also been put to use, wildlife could move to alternative sites should they vacate the same zone in the San Joaquin Valley; and 2) Although centers for the production of various commodities and for livestock were evident in 1930, the spatial distribution of land use practices varied, and it is not evident that particular land use practices could be directly linked to specific soil types or other naturally occurring phenomena that constituted unique habitat types.

In other words, the chances are slim that unique habitat types prevailing in the San Joaquin Valley prior to 1930 were destroyed due to agricultural land use practices. The reasons are that cultivated land constituted but a small part (13 percent) of all valley lands, and only one-third of all lands on the valley floor. Intensively farmed crops comprised still smaller percentages of all lands in the valley (9 percent) and of all lands on the valley floor (21 percent). Production of intensively farmed crops, moreover, was distributed, if not evenly, through both the San Joaquin and Tulare Basins.

The single greatest threat to wildlife habitat from land use was associated with the redistribution and use of surface water supplies in the valley. By diverting waters and constructing dams, weirs and other obstructions to stream flows, man threatened the existence of aquatic biota, including fish and amphibians. By conducting activities that led to the ultimate disappearance of large amounts of wetlands and deep water lakes, man also destroyed habitat for wintering migratory waterfowl and for marsh-nesting avifauna. But again, this did not apparently lead to direct reductions in avifauna populations except locally.

Direct and deliberate actions by man to reduce wildlife populations resulted specifically from the use of poisons within the agricultural sector, and generally in the activities of trappers and hunters. There was, throughout the period under review, a general lack of appreciation for wildlife preservation. Once bountiful populations of game animals and fur bearing mammals thus were reduced or exterminated completely by trappers and hunters. Farmers, motivated more by economic considerations, especially threatened species of non-game mammals and avifauna such as coyotes, wolves, squirrels, and grain-feeding birds such as blackbirds.

Authorities periodically passed legislation, and over time a body of laws accumulated that was designed to protect wildlife. And after 1900 a Division of Fish and Game was established in California. But virtually all attention was given to the preservation of wildlife to enhance sport hunting and fishing. Both authorities and the general public, meanwhile, remained

ambivalent toward the activities of farmers who claimed economic hardships and decimated wildlife populations through the use of poisons and by other means. Years later, legislation would be passed to restrict the use of poisons, and this offered some protection to wildlife. A generation would pass, however, before the public became aware of the acute need for wildlife preservation and sought solutions to problems arising from agricultural land use practices.

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NOTES

1. Evidence relating to the depth of the trough and the physical features of the upper San Joaquin Valley came from core plugs of a well drilled on Sec. 1, T.25S, R.23E, Kern County.

2. Descriptions of the pristine flora provided in this report draw from descriptions given in Crampton (1974); Ornduff (1974); and Burcham (1957).

3. Terms used to identify life zones differ, however the terms Lower Sonoran and Upper Sonoran are still common. A comparison between suggested life zones and current agricultural land use in the San Joaquin Valley is of interest. Compare Figures 6 and 6A.

4. Species identification given in this report follow those provided by the cited authors and may have been changed at later dates.

5. For a collection of maps on explorations in the San Joaquin Valley see Landrum, 1938.

6. The term improved land has had various meanings in census reports, but is herein defined as 'tilled land, including grass in rotation, whether pasture or meadow, fallow lands, permanent meadows and pasture and vineyards'.

7. The claim has been made that 50,000 tons of tules and marsh grasses were cut to provide cattle feed (Burcham, 1957).

8. Cal. Stat., 1874, p. 50.

9. Mention is made in early reports that deforestation occurred between the Mokelumne and Calaveras Rivers where farmers cleared land for farms. Also, many acres of trees fell during the process of clearing land in Stanislaus County. The increase in acres of woodlands on farms reported in the later census reports undoubtedly reflect improved reporting methods rather than increases in woodland areas.

10. Wells in the upper valley were concentrated in the Kings-Kaweah Rivers Deltas (15,531 wells), and at Tulare Lake (1,341 wells).

11. The term full unimpaired run-off is herein defined as 'the run-off that would have occurred under natural conditions, i.e., in the absence of dams or the withdrawal of waters from streams for irrigation and other purposes'.

12. And owners have spent millions of dollars trying to protect the area. See Fresno Bee, 1987.

13. Originally investigators believed Tulare Lake water levels would be maintained in part by upland irrigation which supported the flow of sub-surface waters running into the trough. Further investigations disproved this theory. Apparently a north-south lobe extends along the east side of the lake and prevents underflows from reaching the lake. Withdrawal of waters by pumping from aquifers would not effect the lake either. Upland irrigation, therefore, only impacted the lake as surface supplies on streams running into the lake were diverted.

14. Poisons distributed to reduce squirrel numbers killed rodents as well. Especially effected were the Long-tailed Harvest Mouse (Reithrodontomys megalotis longicauda), Gambel White-footed Mouse (Peromyscus maniculatus gabeli), Stevens Canyon Mouse (Peromyscus crinitus stephensi), Intermediate Wood Rat (Neotoma intermedia intermedia), Norway Rat (Epimys norvegicus), and several rodents believed to be endemic to valley, including the Los Baños Pocket Gopher (Thomomys angularis angularis), San Joaquin Pocket Mouse (Perognathus longimembris longimembris), McKittrick Pocket Mouse (Perognathus longimembris), Kern County Pocket Mouse (Perognathus californicus ochrus), Tulare Kangaroo Rat (Perodipus agilis tularensis), Carrizo Plain Kangaroo Rat (Perodipus ingens), Kern Valley Kangaroo Rat (Dipodomys merriami kernensis), Tipton Kangaroo Rat (Dipodomys merriami nitratoides), identified by Stevens (1906) as the Tulare Kangaroo Rat, Kern Valley Kangaroo Rat (Dipodomys merriami kernensis), and the Fresno Kangaroo Rat (Dipodomys merriami exitis) (Grinnell, 1913).

15. An important factor in the large kills of avifauna by hunters was the continuing efforts of arms manufacturers to improve weapons. Throughout the years both guns and ammunition became more powerful. (Chambers, 1936)

16. The Southern Pacific Railroad published pamphlets touting the availability of wildlife and assessed various areas to encourage hunting (Southern Pacific Company, 1896).

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Figures

GEOLOGIC TIME SCALE

ERA	PERIOD	EPOCH	DATES, YEARS
		HOLOCENE (Recent)	50,000
	QUATERNARY		
		PLEISTOCENE	1,000,000
CENOZOIC			
		PLIOCENE	12,000,000
		MIOCENE	30,000,000
	TERITARY		
		OLIGOCENE	40,000,000
		EOCENE & PALEOCENE	60,000,000

Figure 1

TERTIARY LAKES

After Durrenberger, 1968

Figure 2

PRISTINE OVERFLOW LANDS

Overflow lands on Kaveah and Tule Rivers not shown. From California, Dept. Public Works, 1931.

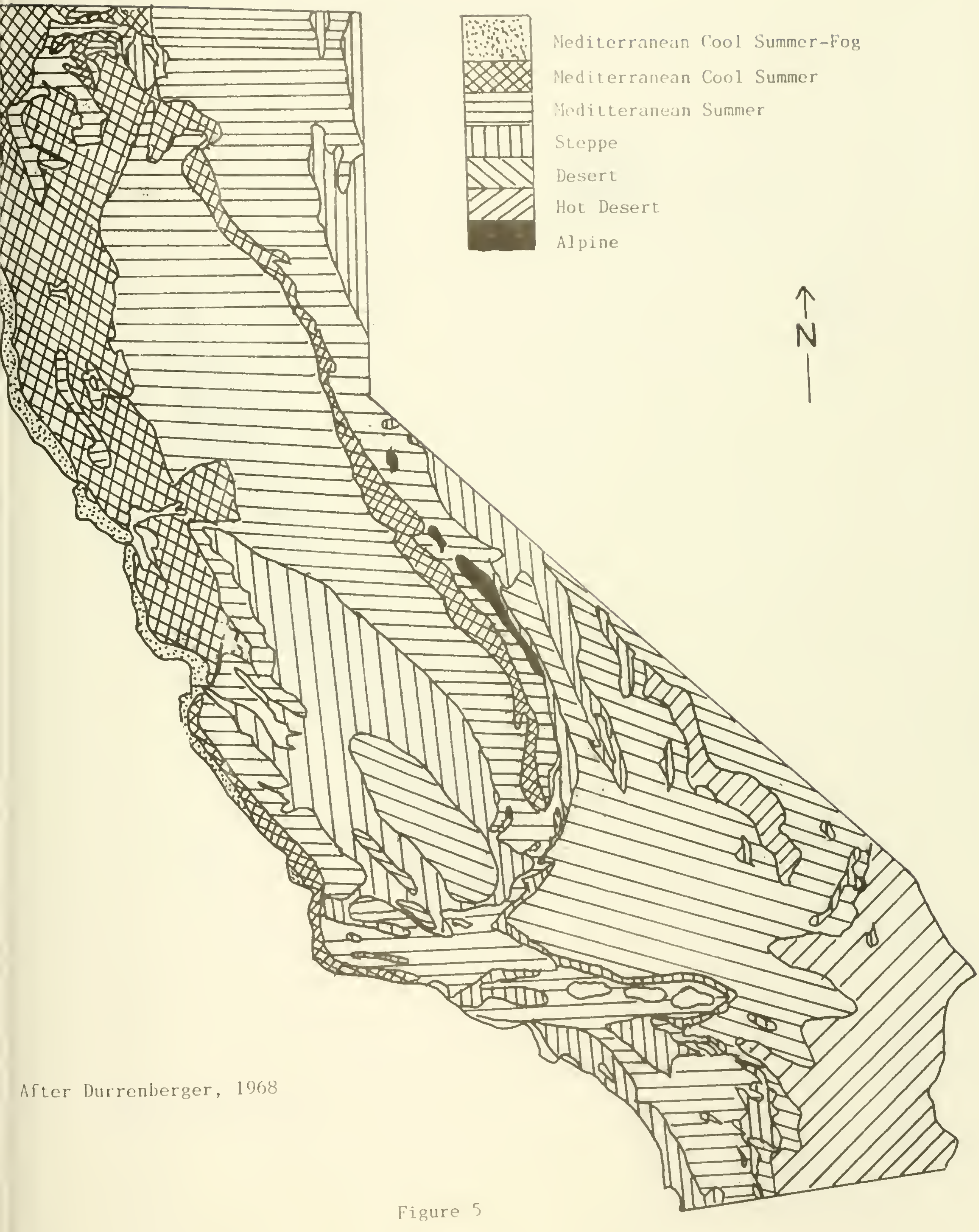
Figure 3

MEAN ANNUAL PRECIPITATION, CALIFORNIA, mid-1960's

From Durrenberger, 1968

Figure 4

CLIMATIC REGIONS, CALIFORNIA



After Durrenberger, 1968

Figure 5

SUGGESTED FAUNAL LIFE-ZONES,
CENTRAL VALLEY, CALIFORNIA

From Grinnell, 1935

Figure 6

GENERAL AREA,
DEVELOPED AGRICULTURAL LANDS,
SAN JOAQUIN VALLEY, CALIFORNIA,
1980's

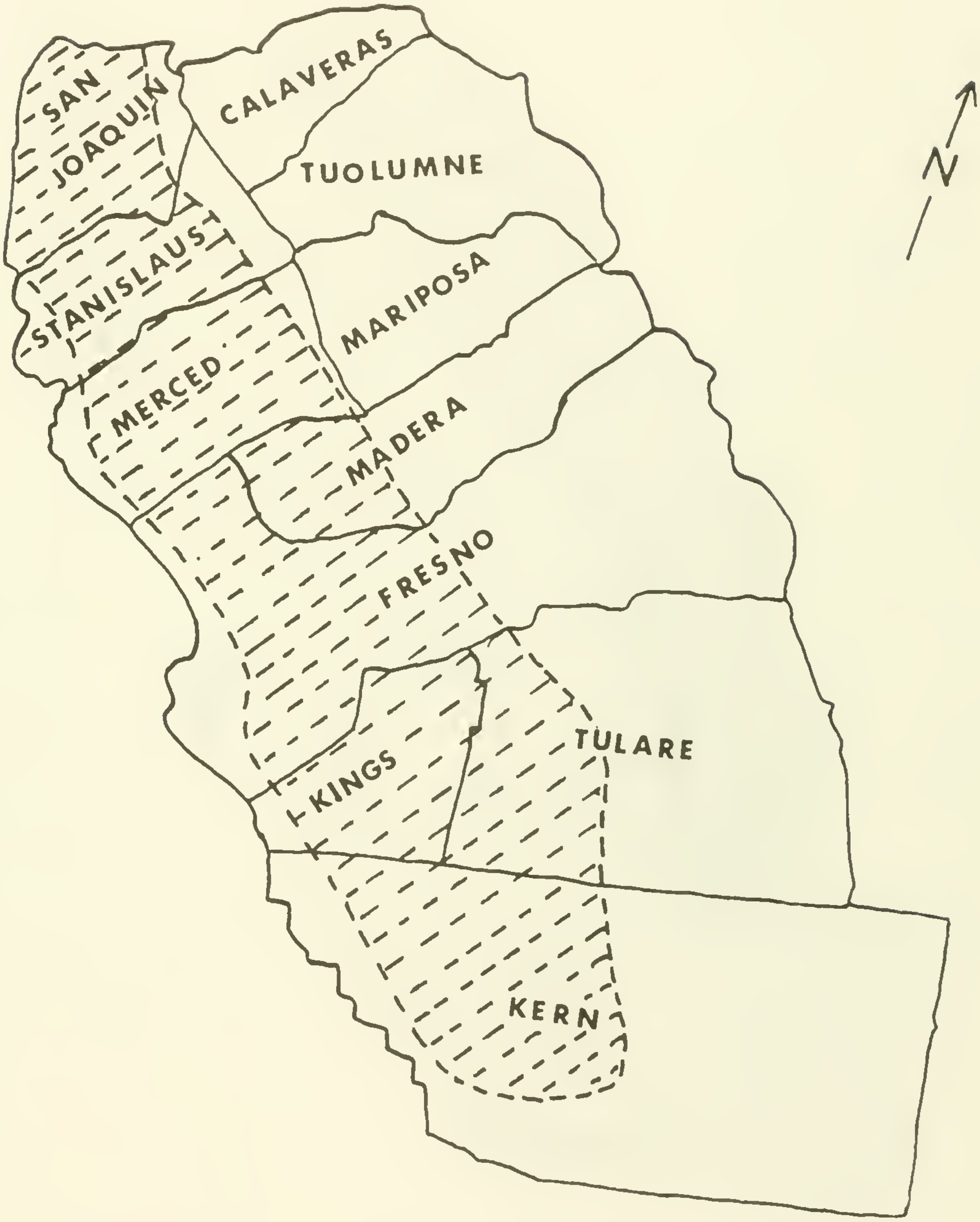
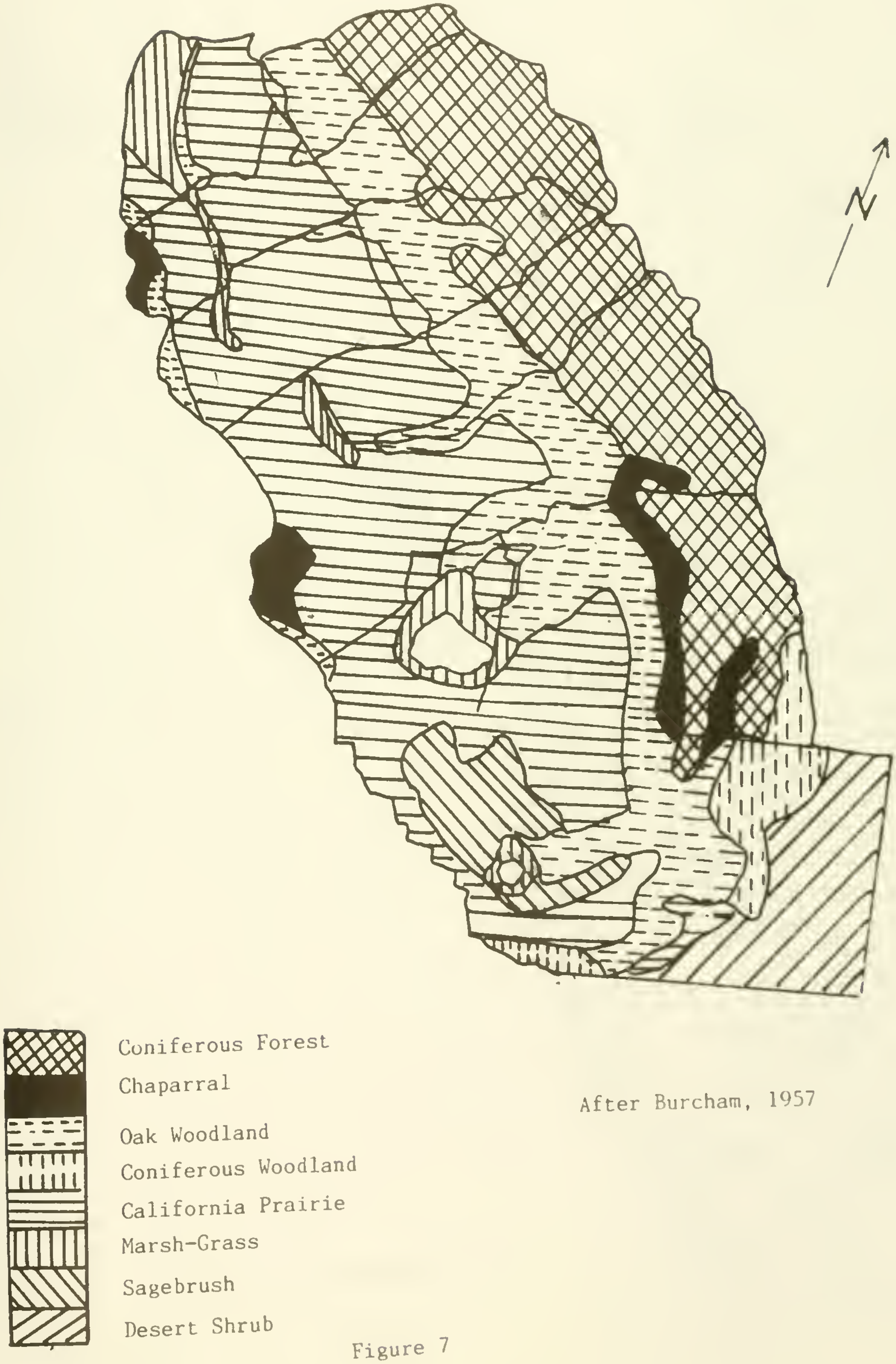


Figure 6A

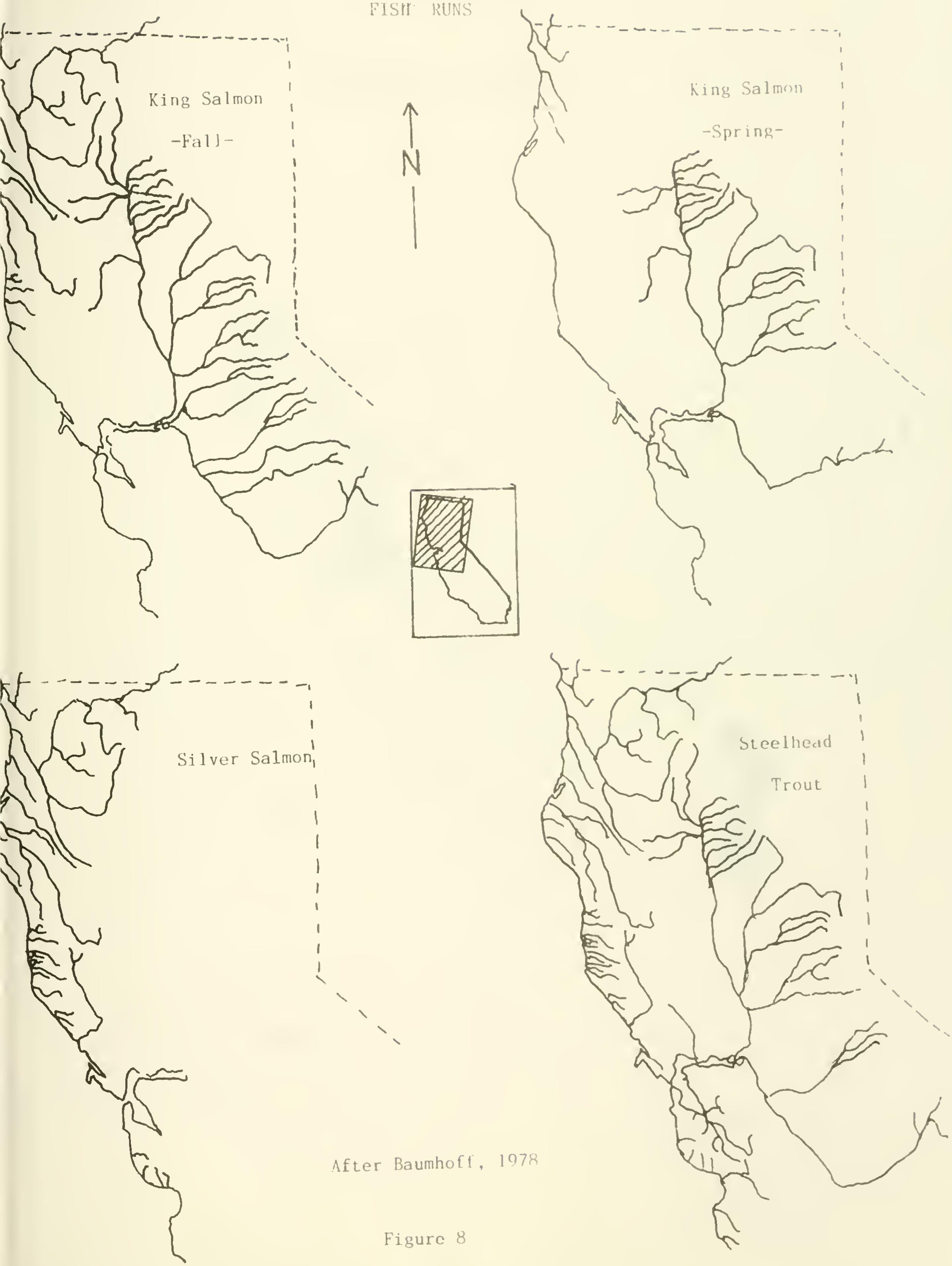
APPROXIMATE EXTENT AND LOCATION
PRISTINE VEGETATION-SAN JOAQUIN
VALLEY, CALIFORNIA



After Burcham, 1957

Figure 7

PRISTINE ANADROMOUS
FISH RUNS



After Baumhoff, 1978

Figure 8

AVERAGE ANNUAL STREAMFLOW,
CALIFORNIA, mid-1960's

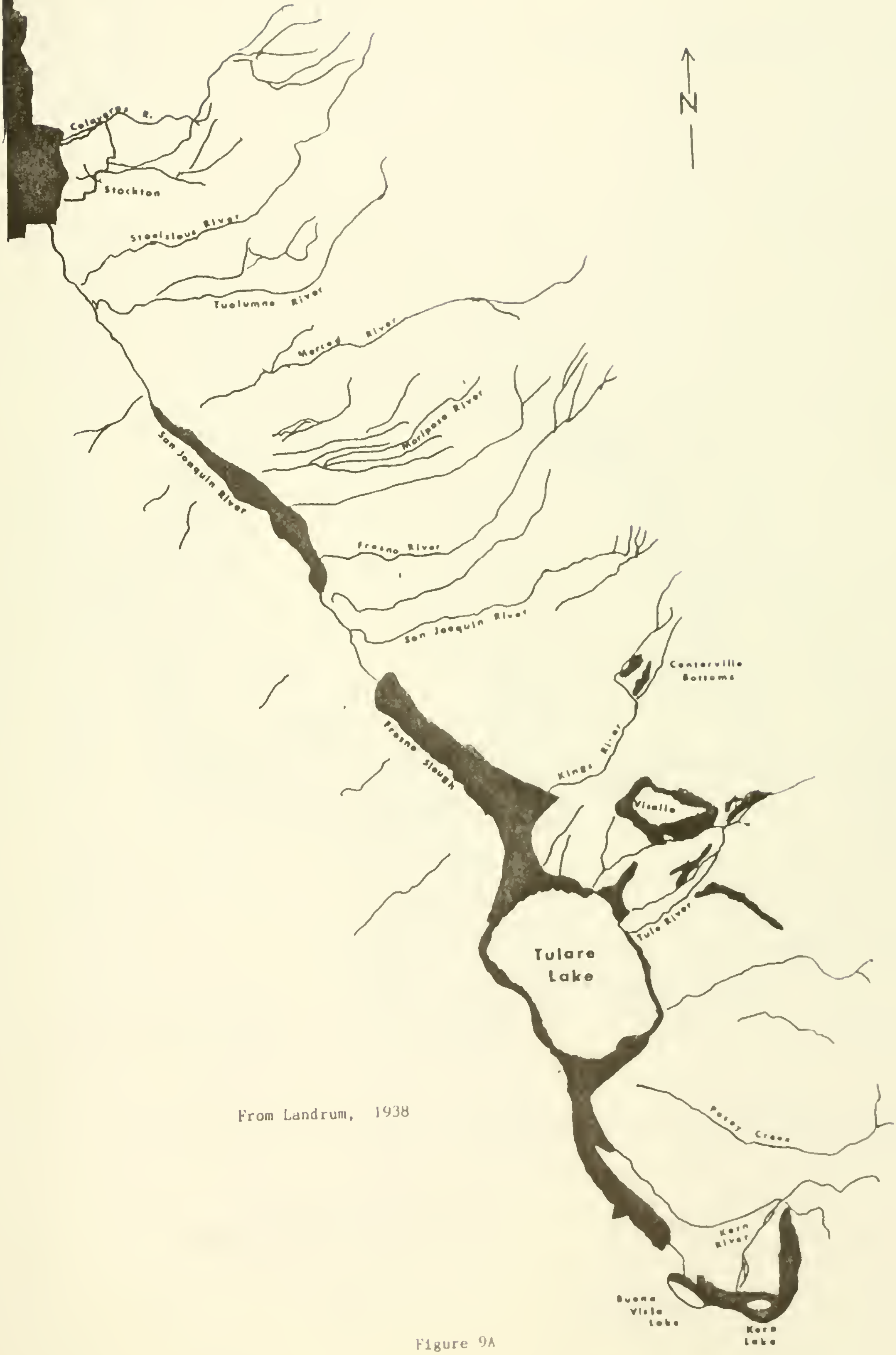
-- 100,000 to 500,000 acre feet

▬ 500,000 + acre feet

After Durrenberger, 1968

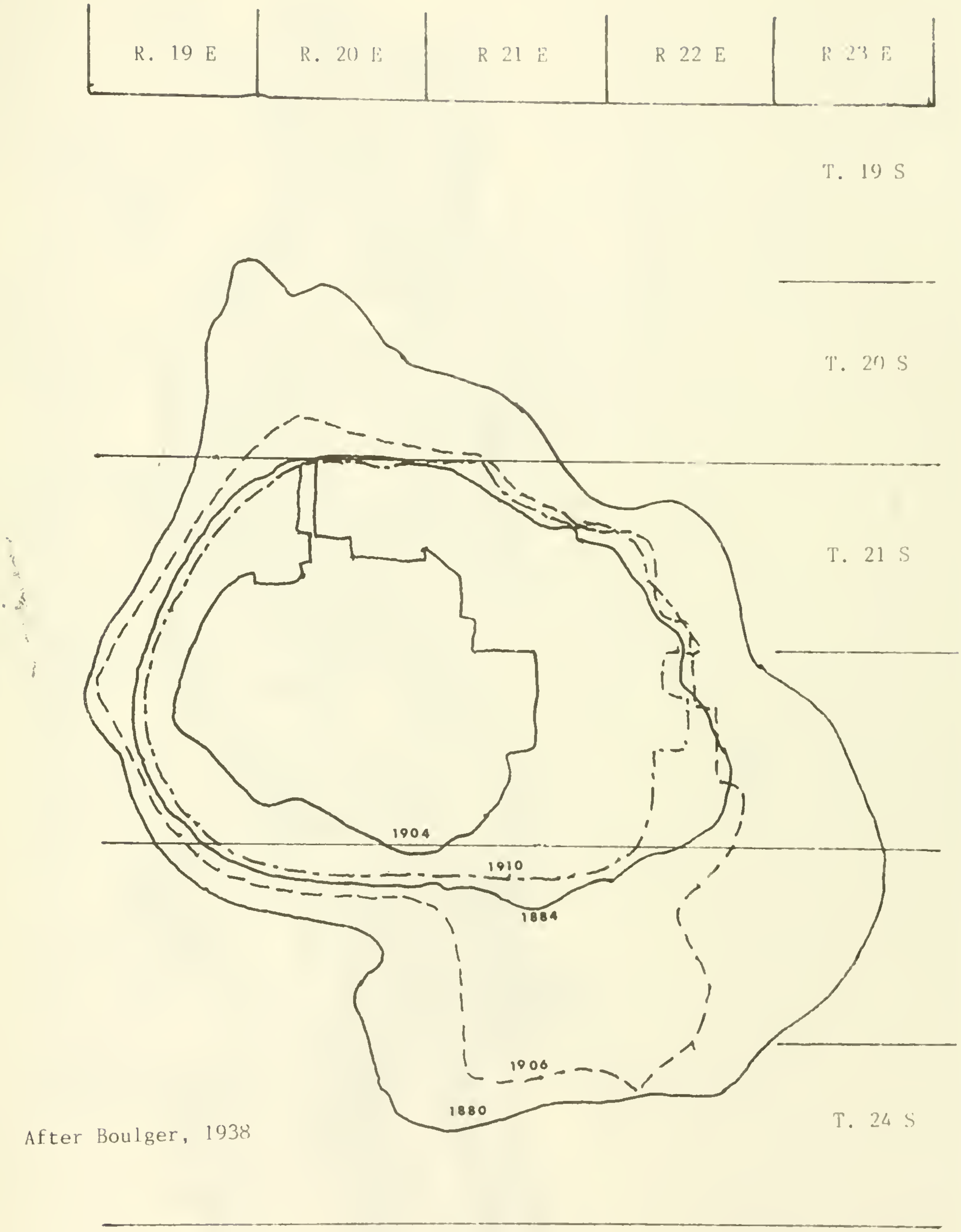
Figure 9

WETLANDS, SAN JOAQUIN
VALLEY, 1859



From Landrum, 1938

Figure 9A



MARGINS, TULARE LAKE,
SELECTED YEARS

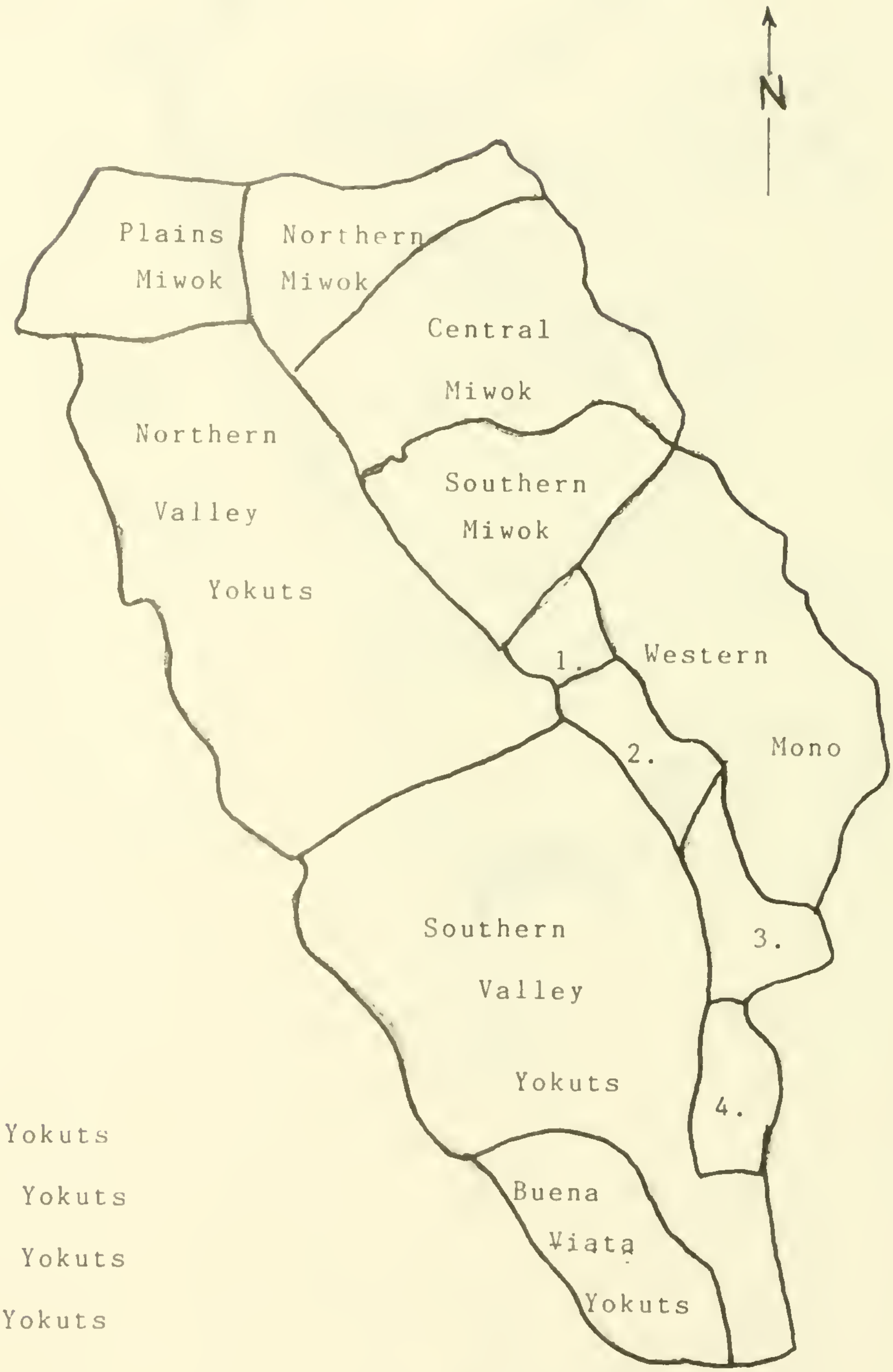
Figure 10

AGRICULTURAL LANDS CLASSIFICATION
SAN JOAQUIN VALLEY, 1930

From. California, Dept. Public Works. 1931

Figure 11

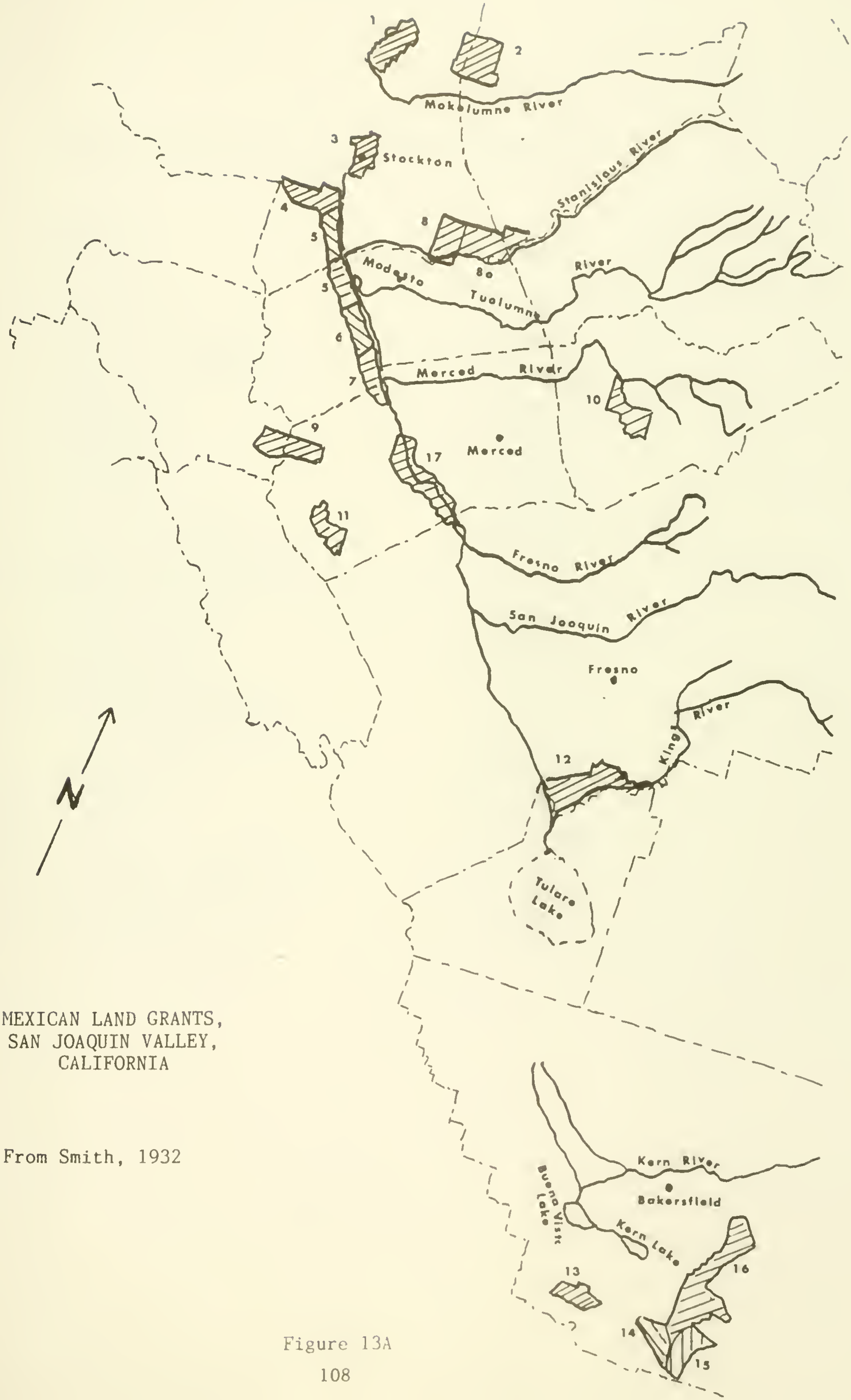
INDIAN CULTURAL PROVINCES
SAN JOAQUIN VALLEY, CALIFORNIA



1, North Hill Yokuts
2. Kings River Yokuts
3. Tule-Kaweah Yokuts
4. Poso Creek Yokuts

After Baumhoff, 1963

Figure 12



MEXICAN LAND GRANTS,
SAN JOAQUIN VALLEY,
CALIFORNIA

From Smith, 1932

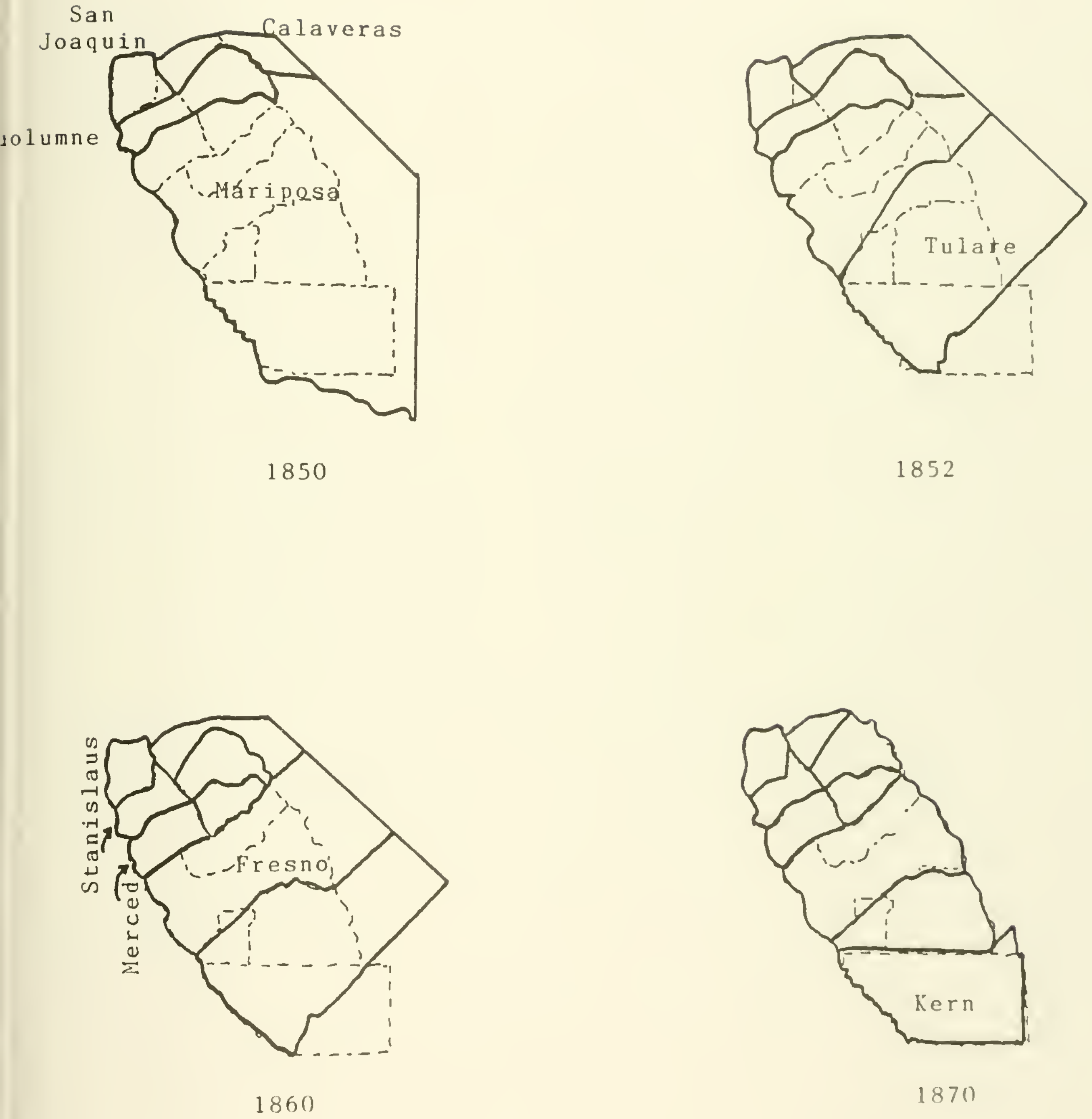
Figure 13A

Mexican Land Grants, San Joaquin Valley, California

	Name	Acreage
1.	Arroyo Seco	48,857.52
2.	Canada de los Vaqueros	48,456.92
3.	Rancho de los Franceses	48,747.03
4.	El Pescadero	35,546.39
5.	El Pescadero	35,446.06
6.	Rancho del Puerto	13,340.34
7.	Orestimba	26,641.17
8.	Land On the Stanislaus River	35,532.80
8a.	Rancho de Rio Esanislao (San Joaquin and Stanislaus Grant)	48,889.46
9.	San Luis Gonzaga	48,821.43
10.	Las Mariposas	44,386.83
11.	La Panoche de San Juan y los Carrisalitos	22,450.04
12.	Laguna de Tache	48,800.62
13.	San Emidio	17,709.79
14.	Castac	21,700.09
15.	Los Alamos y Agua Caliente	26,040.14
16.	El Tejon	95,480.10
17.	Sanjon de Santa Rita	48,823.84

Figure 13B

COUNTY BOUNDARY ADJUSTMENTS
SAN JOAQUIN VALLEY, 1850-1910



After Beck and Haase, 1974

Figure 14A

1880

1890

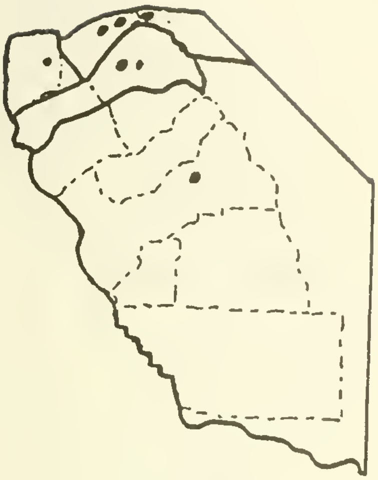
1900

1910

Figure 14B

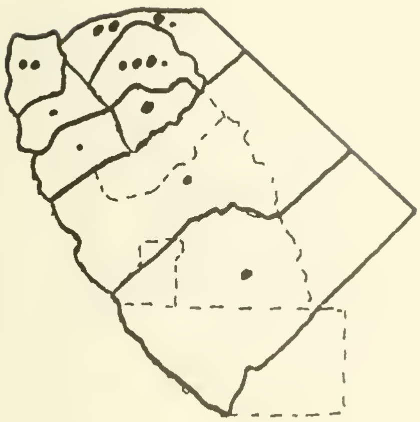
POPULATION DISTRIBUTION
SAN JOAQUIN VALLEY, 1850-1930

(1 dot equals 5,000 inhabitants)



1850

1852



1860

1870

From U.S. Census

Figure 15A

1880

1890

1900

1910

Fugure 15B

1920

1930

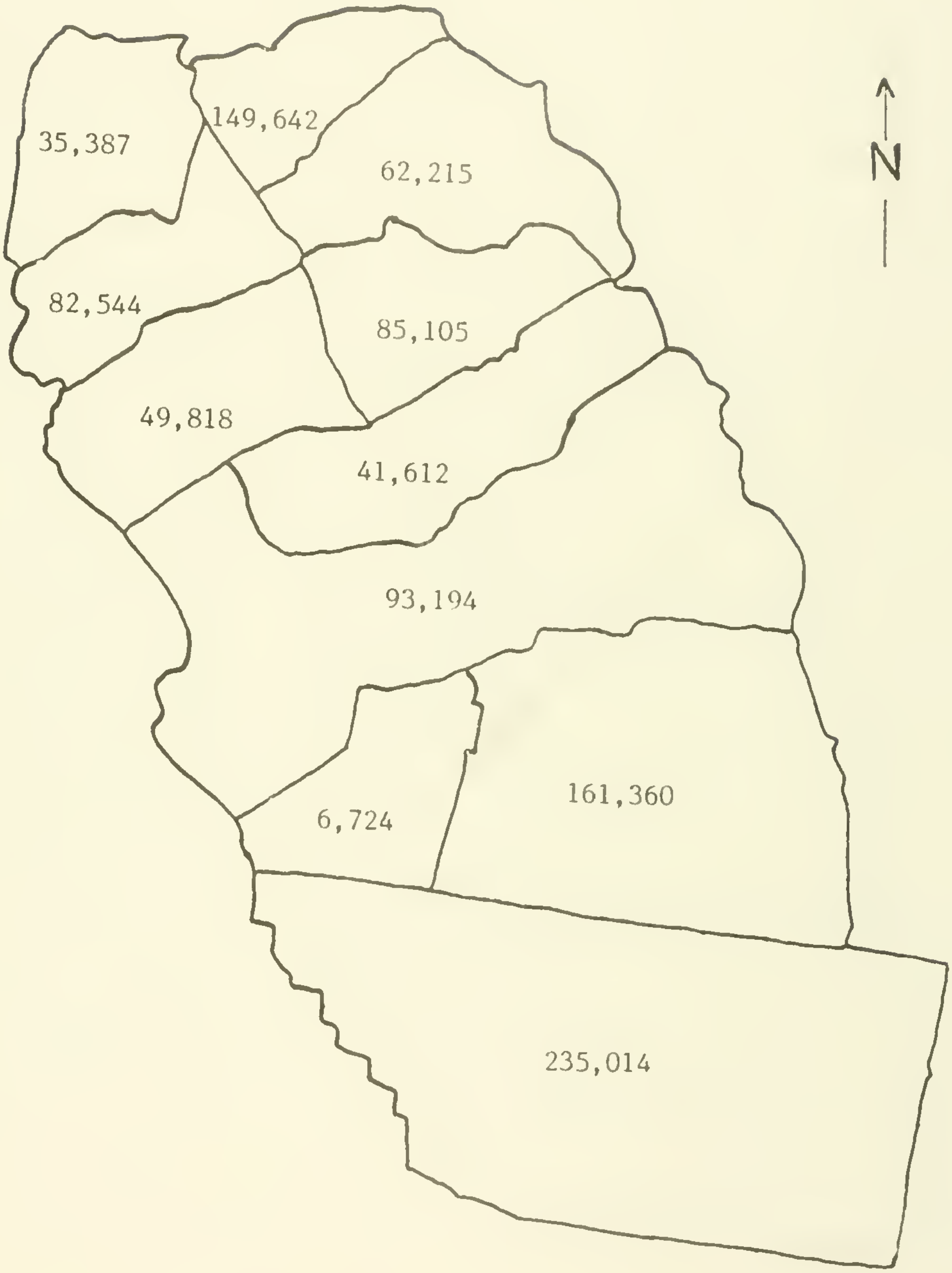
Figure 15C

FARM WOODLANDS, SAN JOAQUIN
VALLEY, 1870, 1910-1930
(Acres)

1870

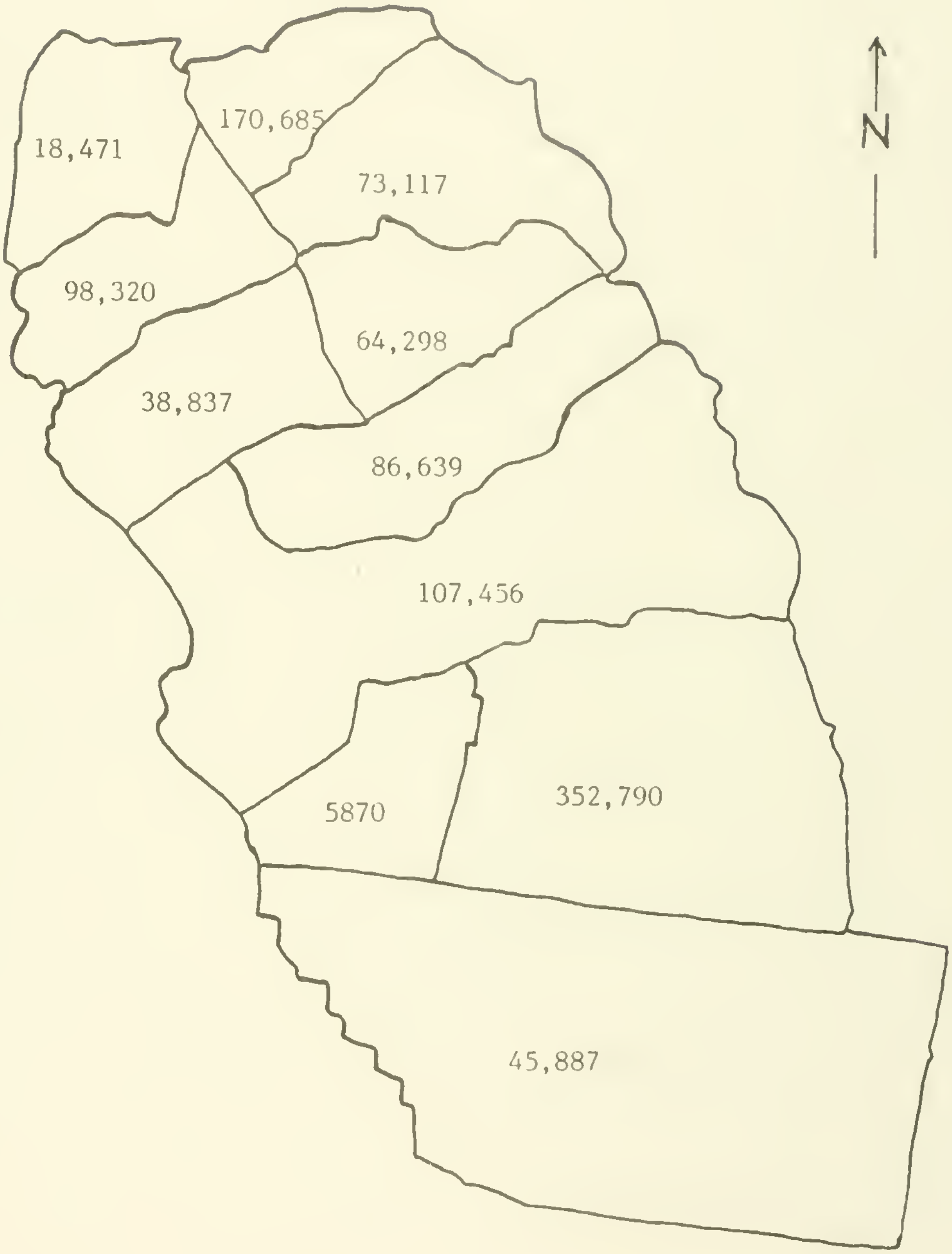
From U.S. Census

Figure 16A



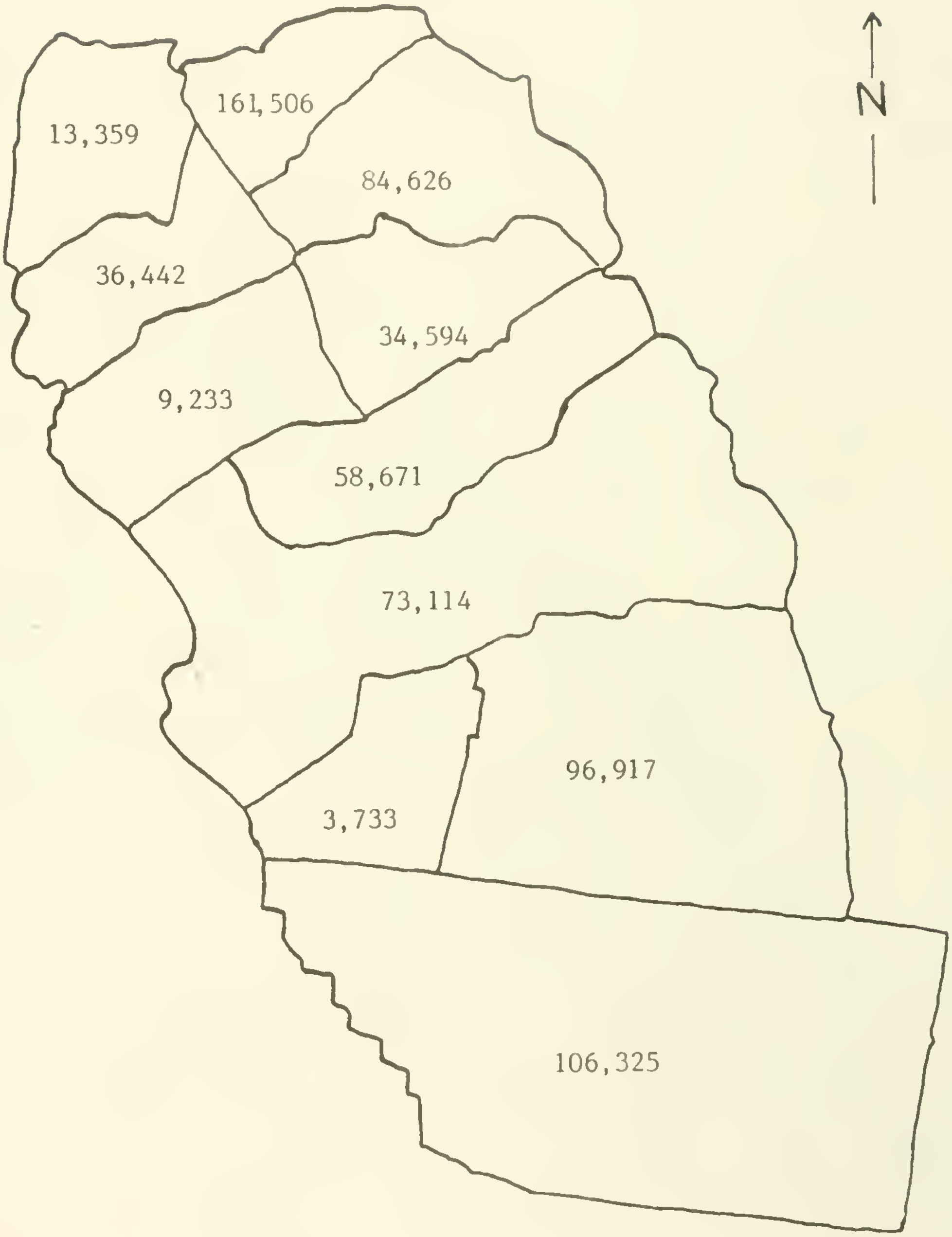
1910

Figure 16B



1920

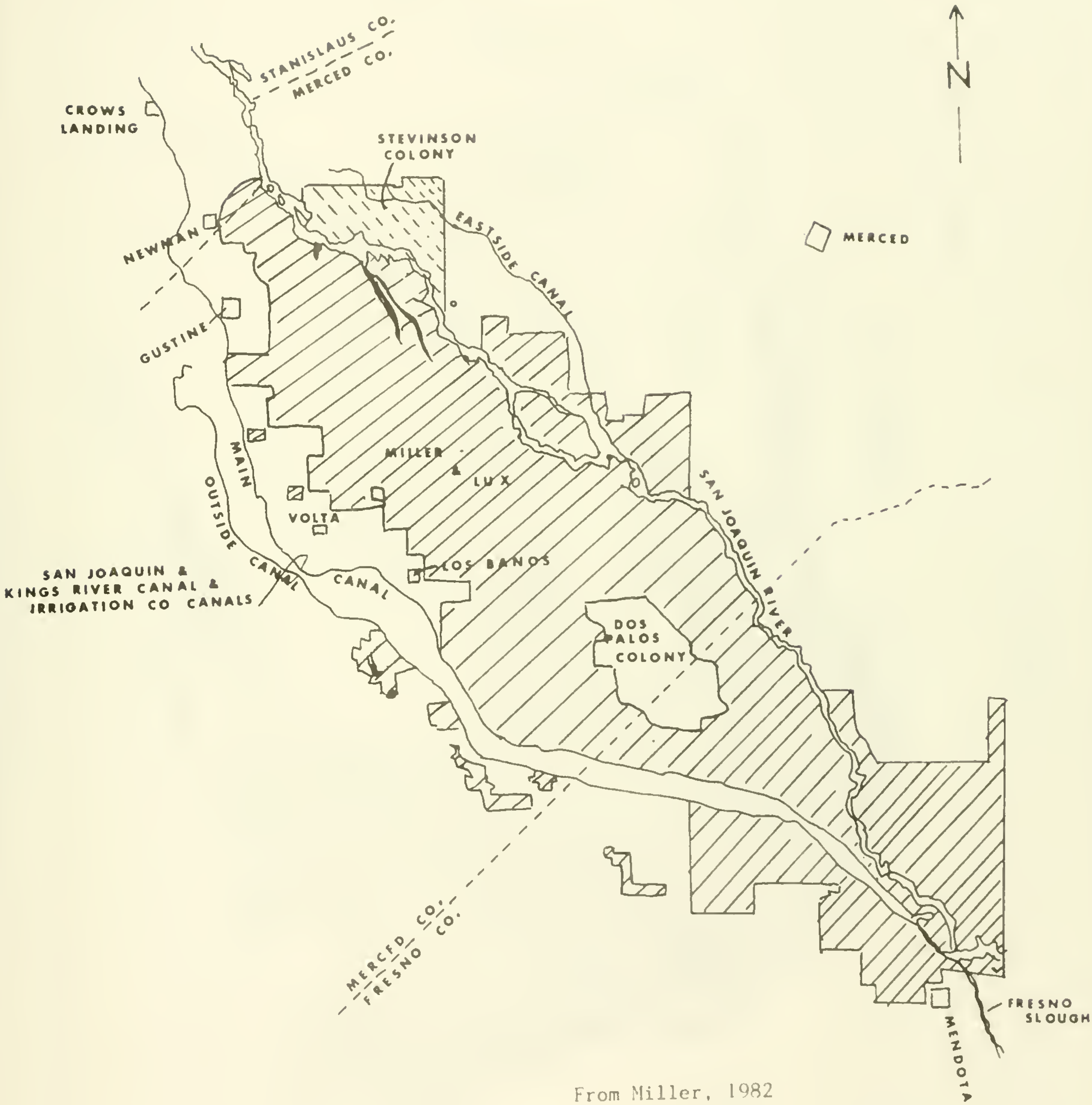
Figure 16C



1930

Figure 16D

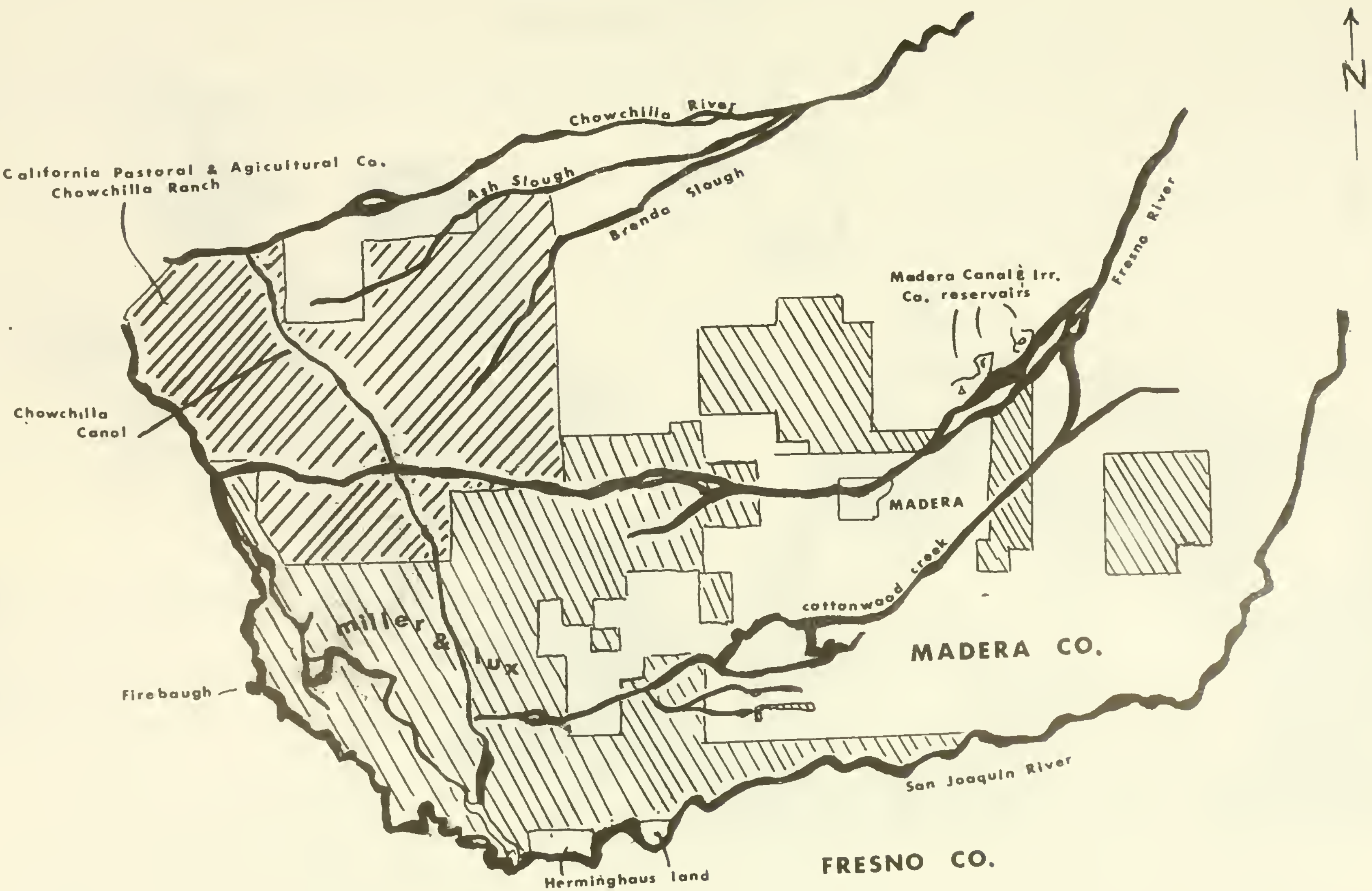
MAJOR LAND HOLDINGS, MERCED COUNTY, SAN JOAQUIN VALLEY, circa 1916



From Miller, 1982

Figure 17A

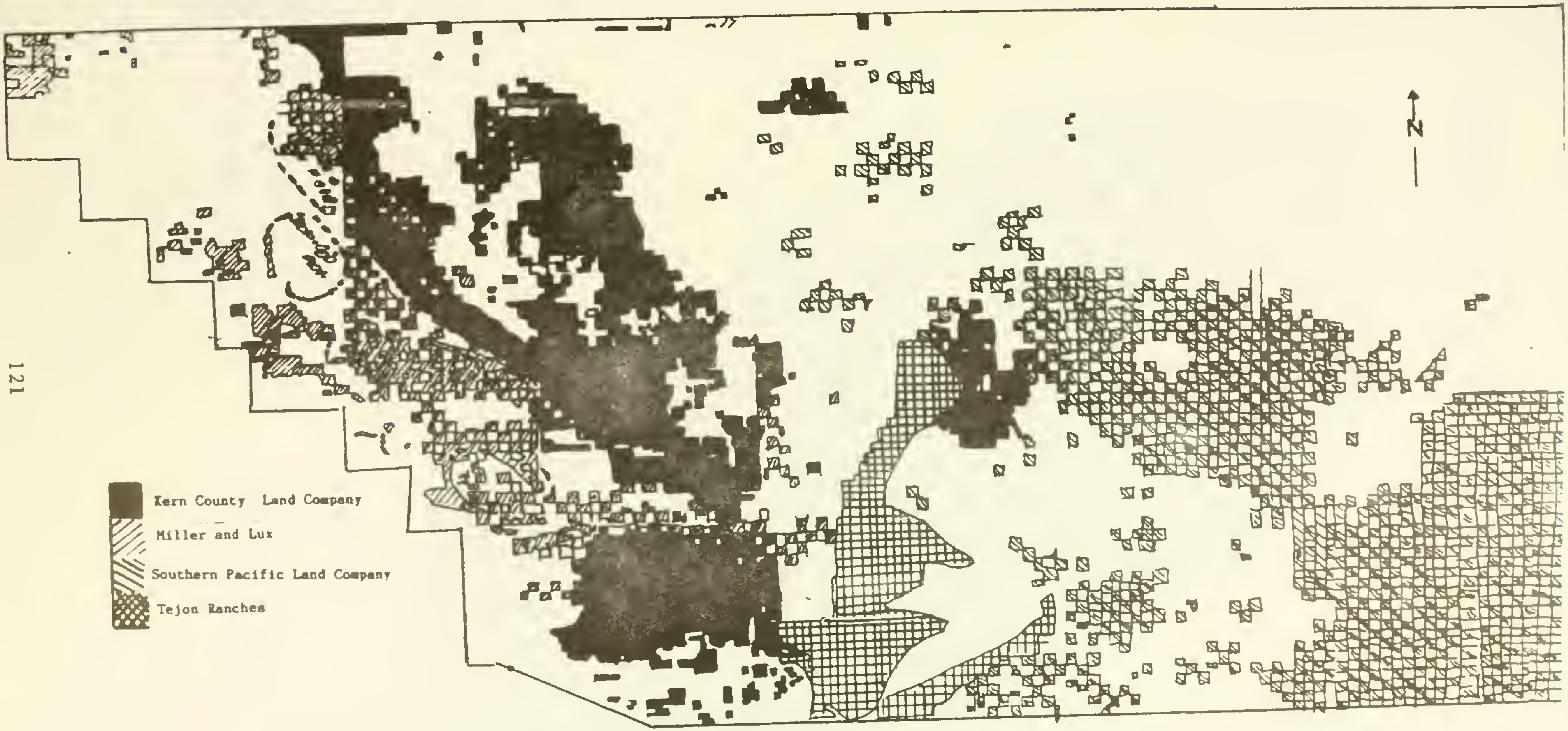
MAJOR LAND HOLDINGS, MADERA COUNTY, SAN JOAQUIN VALLEY, 1898



From Miller, 1982

Figure 17B

MAJOR LAND HOLDINGS, KERN COUNTY,
SAN JOAQUIN VALLEY, circa 1914

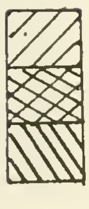


From *Morning Echo*, 1914

Figure 17C

IRRIGATED FARMS AS A PERCENT OF ALL FARMS, BY COUNTY, SAN JOAQUIN VALLEY, 1890-1930

1890



From U.S. Census

Figure 18A

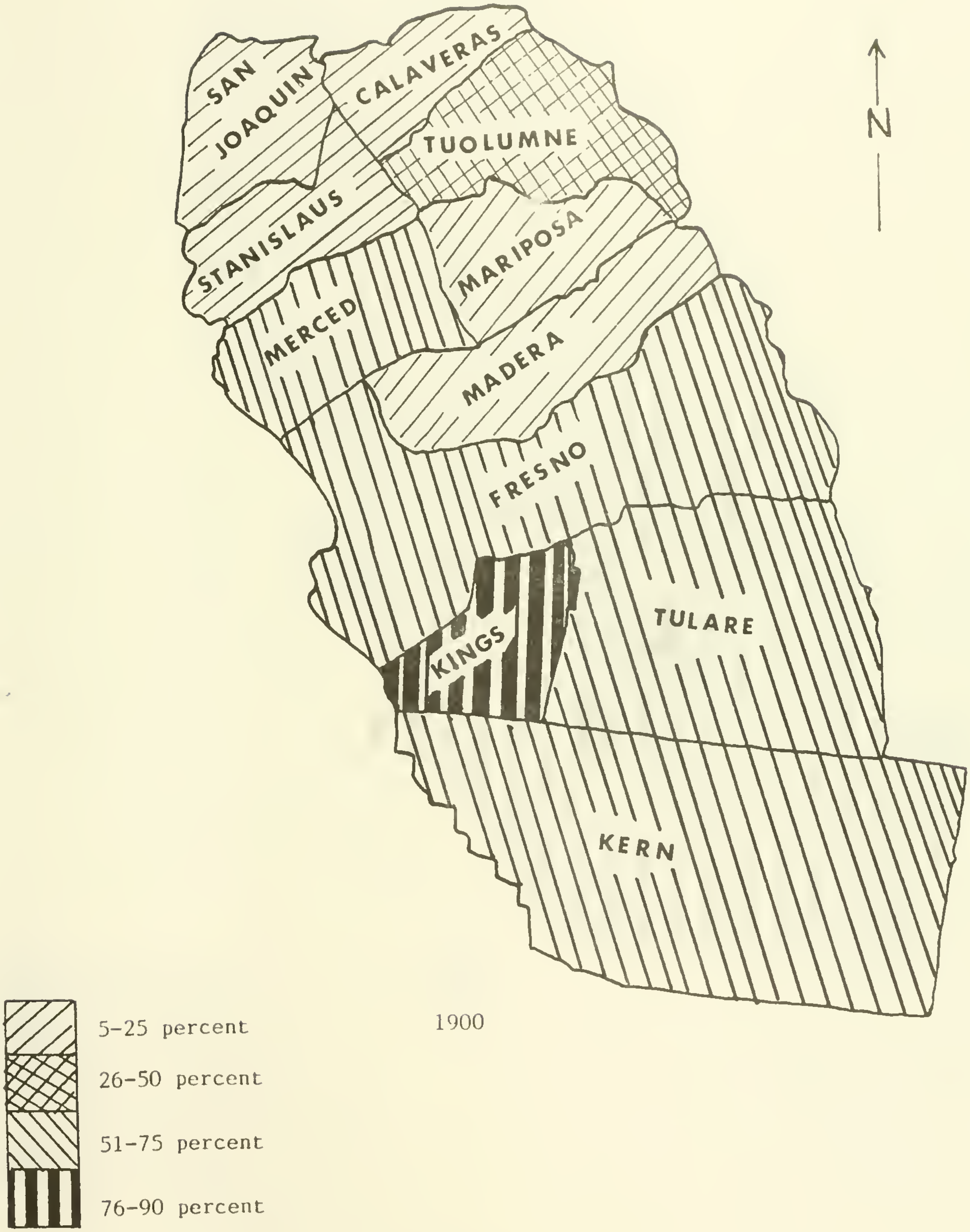

SAN JOAQUIN
CALAVERAS
TUOLUMNE
STANISLAUS
MARIPOSA
MERCED
MADERA
FRESNO
KINGS
TULARE
KERN
N
5-25 percent
26-50 percent
51-75 percent
76-90 percent
1900

Figure 18B


N
SAN JOAQUIN
CALAVERAS
TUOLUMNE
STANISLAUS
MARIPOSA
MERCED
MADERA
FRESNO
KINGS
TULARE
KERN
5-25 percent
26-50 percent
51-75 percent
76-90 percent
1910

Figure 18C

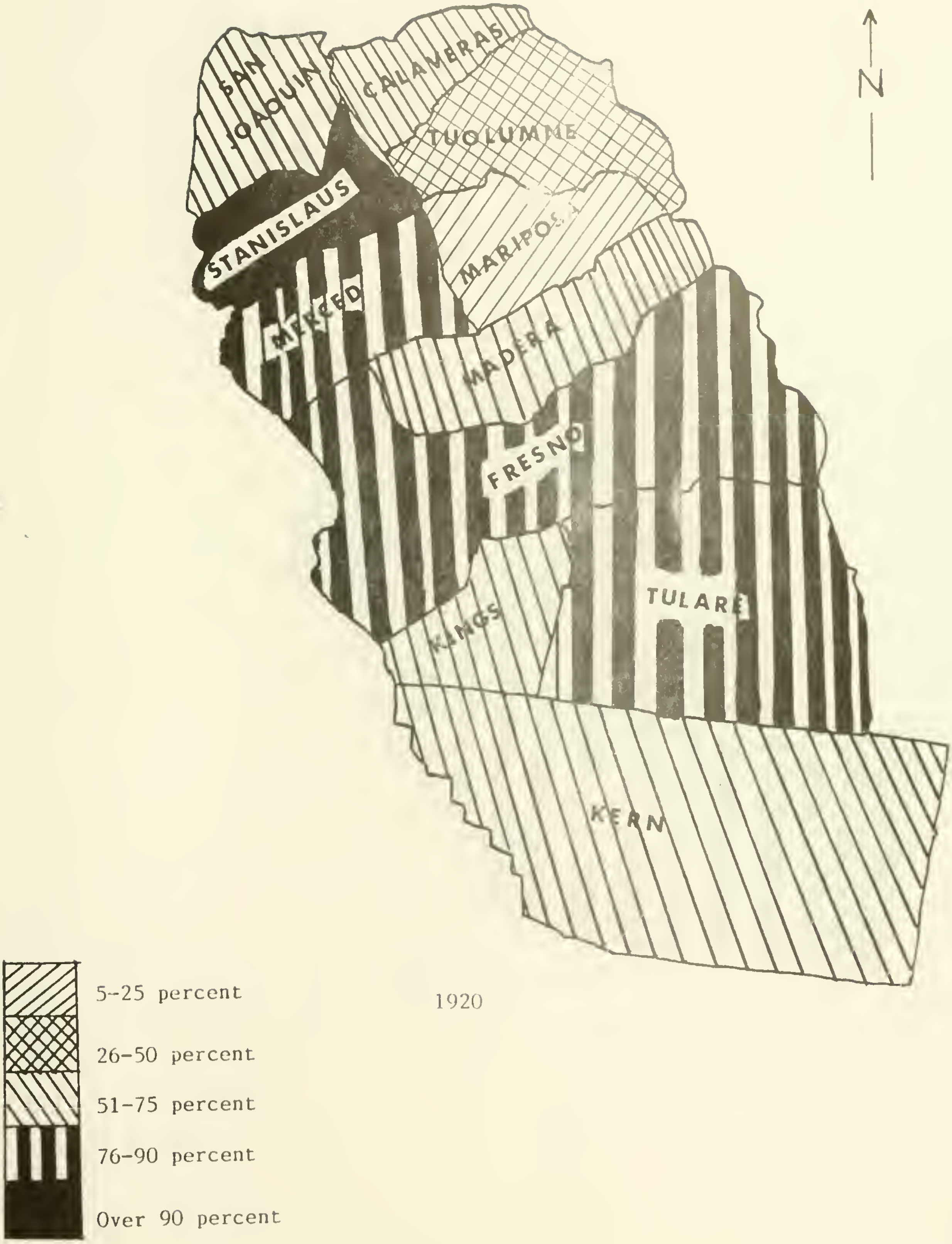

N
SAN JOAQUIN
CALAVERAS
TUOLUMNE
STANISLAUS
MARIPOSA
MERCED
MADERA
FRESNO
TULARE
KINGS
KERN
1920
5-25 percent
26-50 percent
51-75 percent
76-90 percent
Over 90 percent

Figure 18D

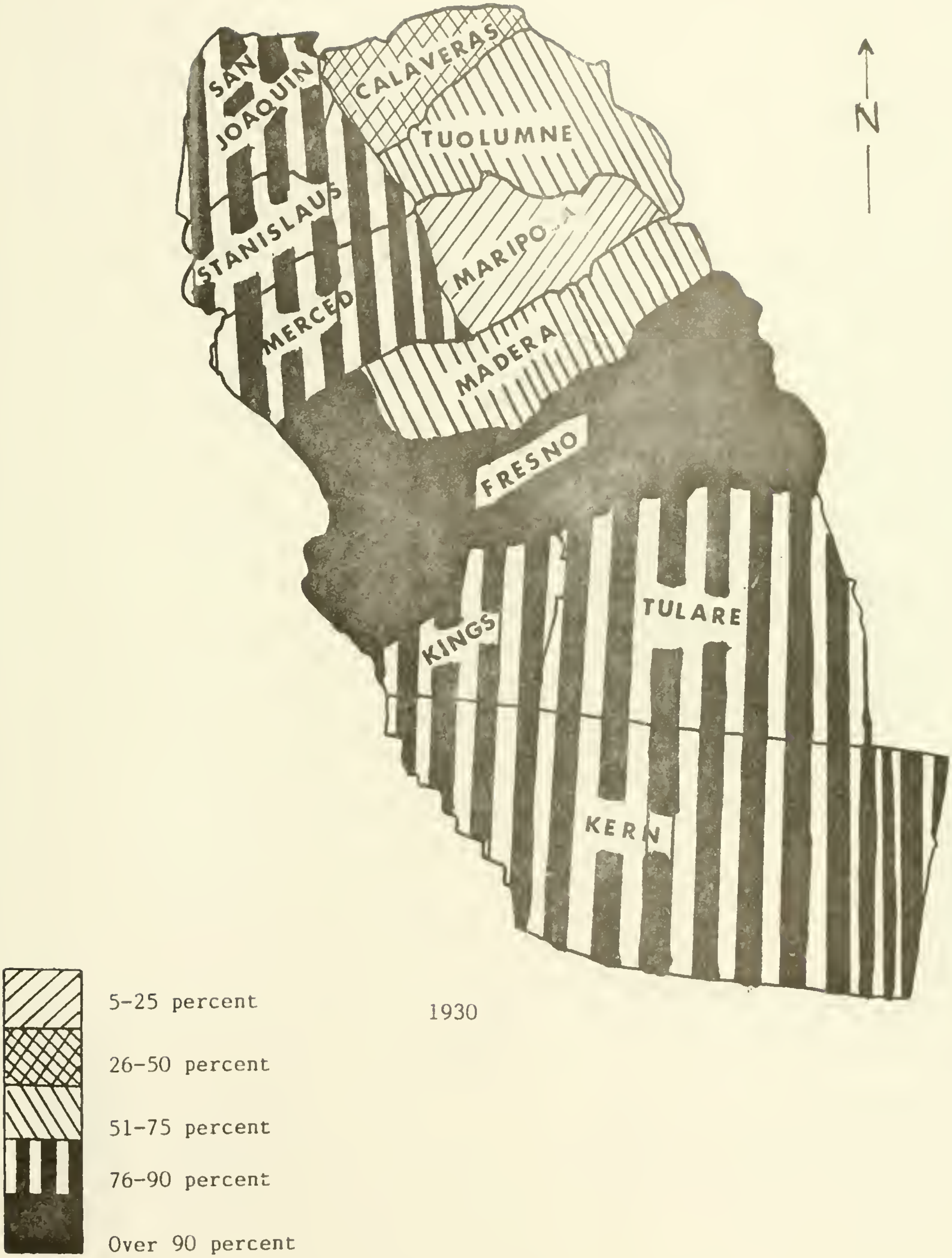
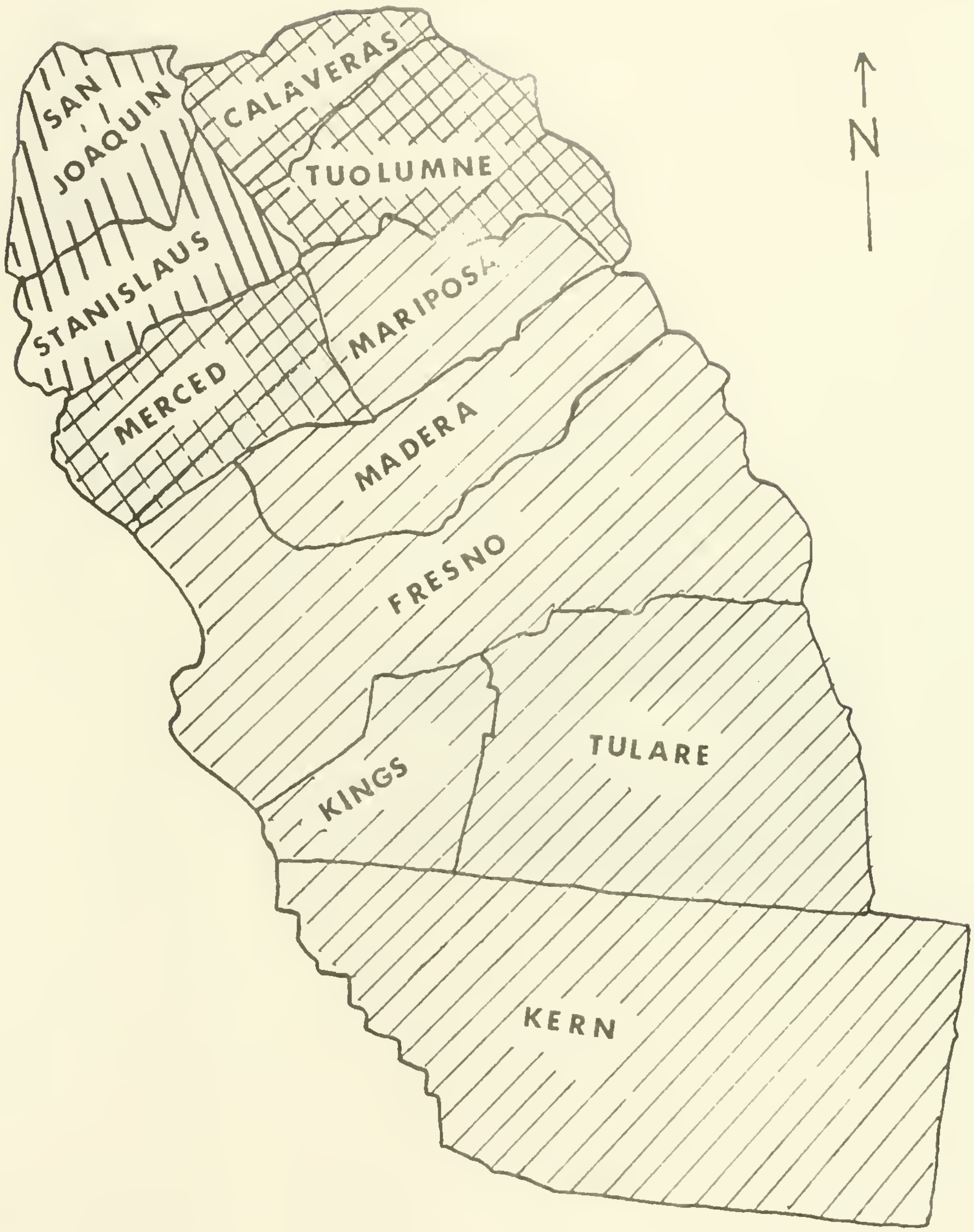

N
SAN JOAQUIN
CALAVERAS
TUOLUMNE
STANISLAUS
MARIPO
MERCED
MADERA
FRESNO
KINGS
TULARE
KERN
1930
5-25 percent
26-50 percent
51-75 percent
76-90 percent
Over 90 percent

Figure 18E

IMPROVED LAND AS A PERCENT OF ALL LAND IN FARMS, BY COUNTY, SAN JOAQUIN VALLEY, 1860-1930



1860

5-25 percent

26-50 percent

51-75 percent

From U.S. Census

Figure 19A

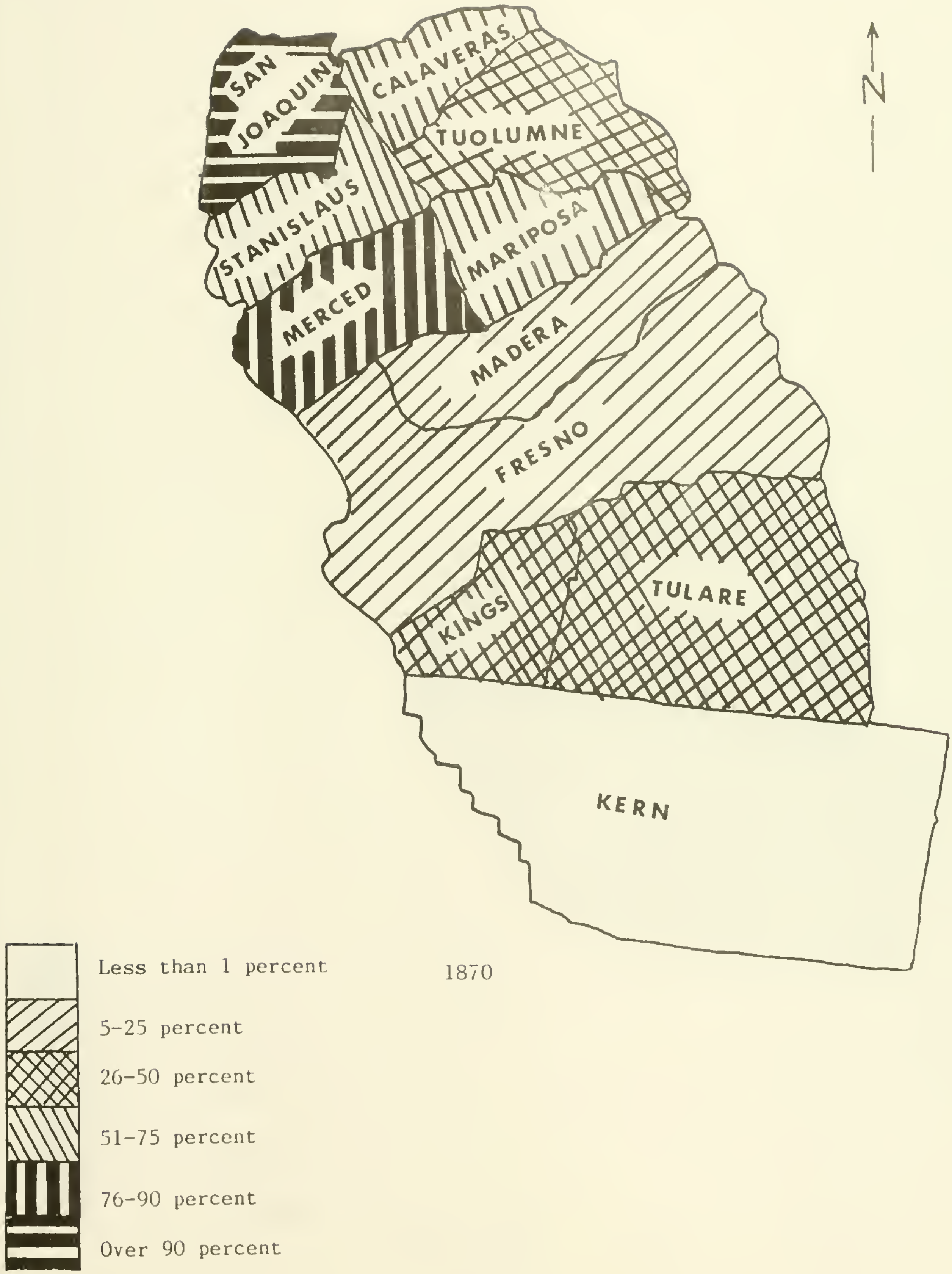
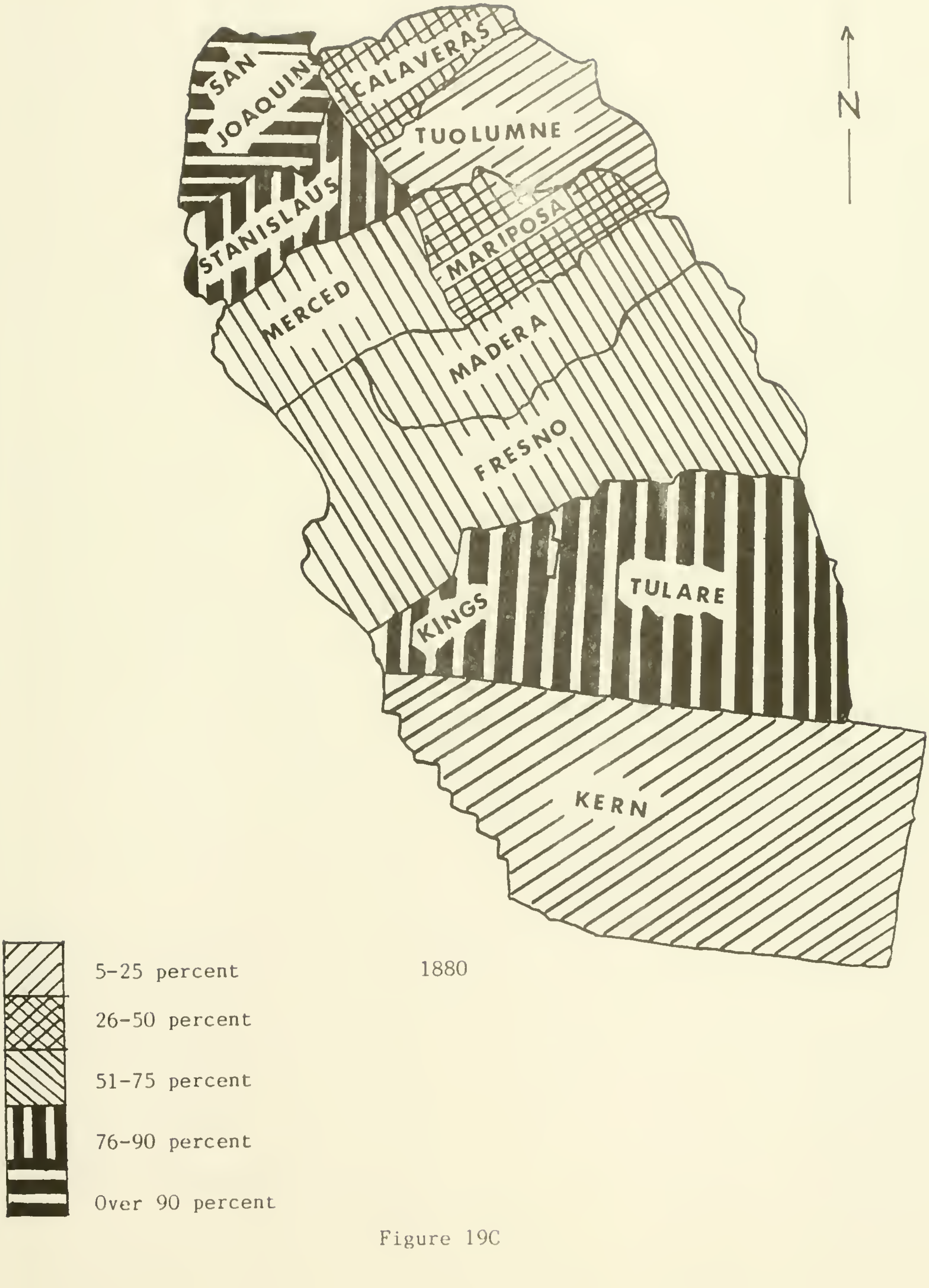

N
SAN JOAQUIN
CALAVERAS
TUOLUMNE
STANISLAUS
MARIPOSA
MERCED
MADERA
FRESNO
KINGS
TULARE
KERN
Less than 1 percent
1870
5-25 percent
26-50 percent
51-75 percent
76-90 percent
Over 90 percent

Figure 19B



1880

Figure 19C

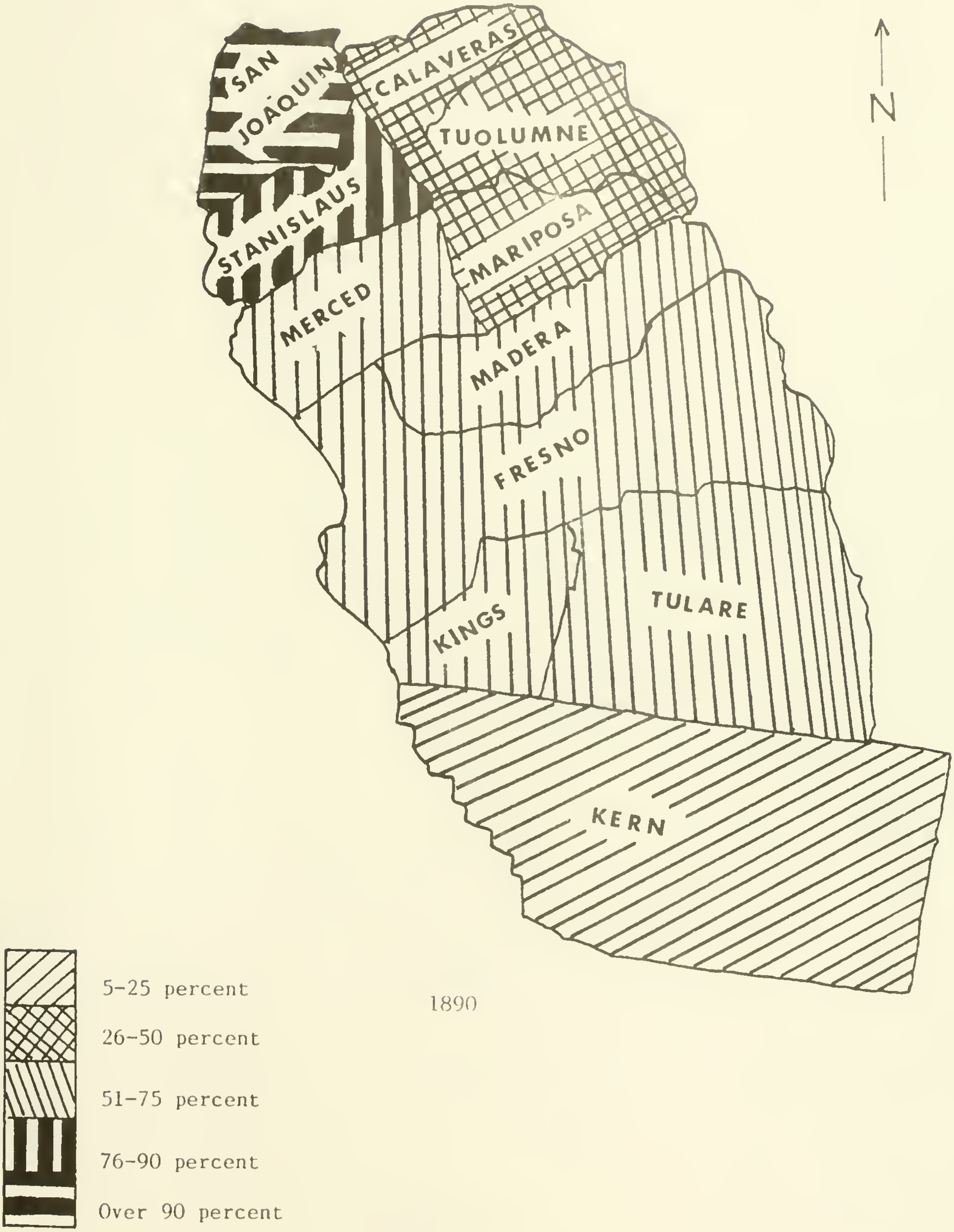

SAN
JOAQUIN
CALAVERAS
TUOLUMNE
STANISLAUS
MARIPOSA
MERCED
MADERA
FRESNO
TULARE
KINGS
KERN
N
5-25 percent
26-50 percent
51-75 percent
76-90 percent
Over 90 percent
1890

Figure 19D

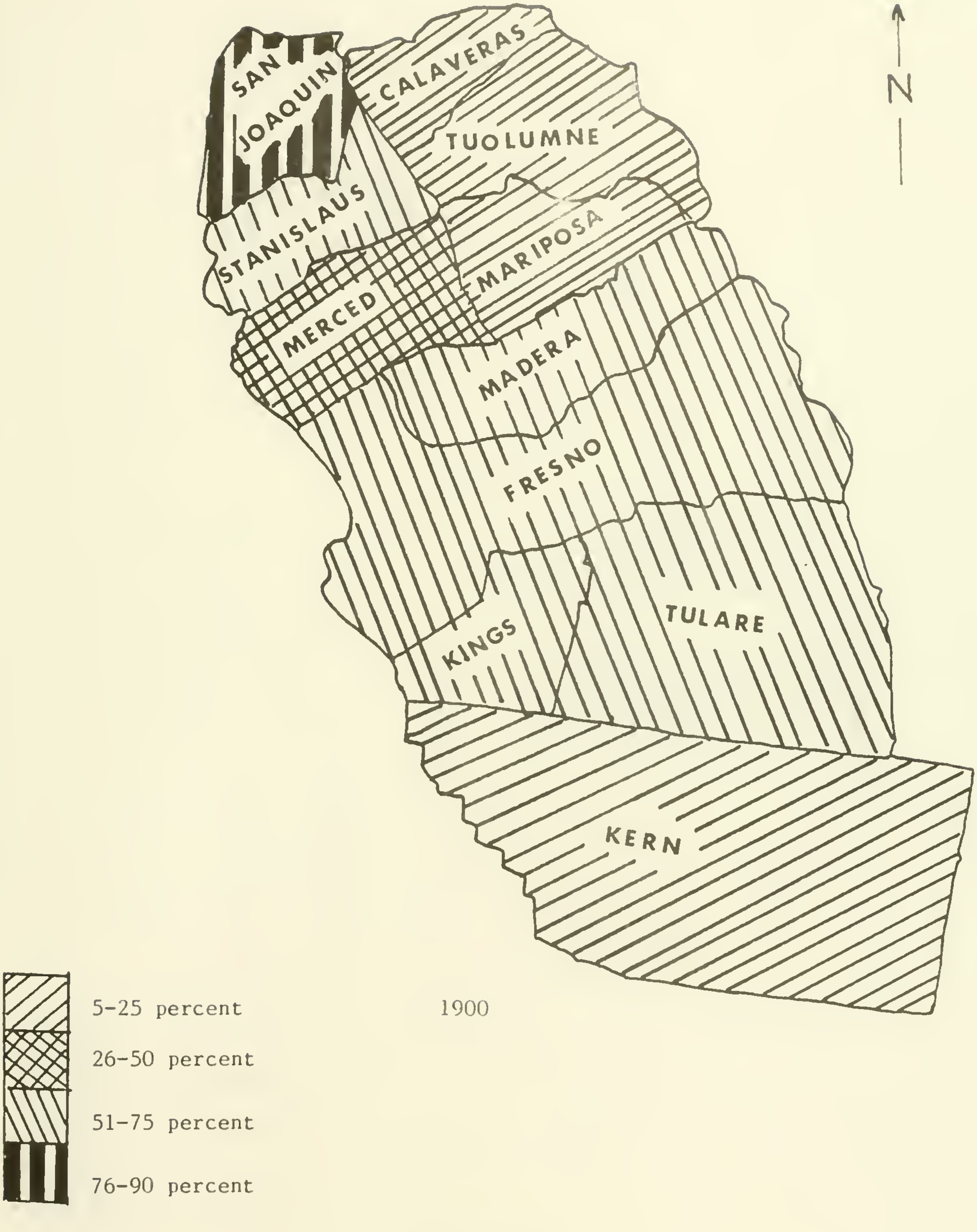

N
SAN JOAQUIN
CALAVERAS
TUOLUMNE
STANISLAUS
MARIPOSA
MERCED
MADERA
FRESNO
KINGS
TULARE
KERN
5-25 percent
26-50 percent
51-75 percent
76-90 percent
1900

Figure 19E

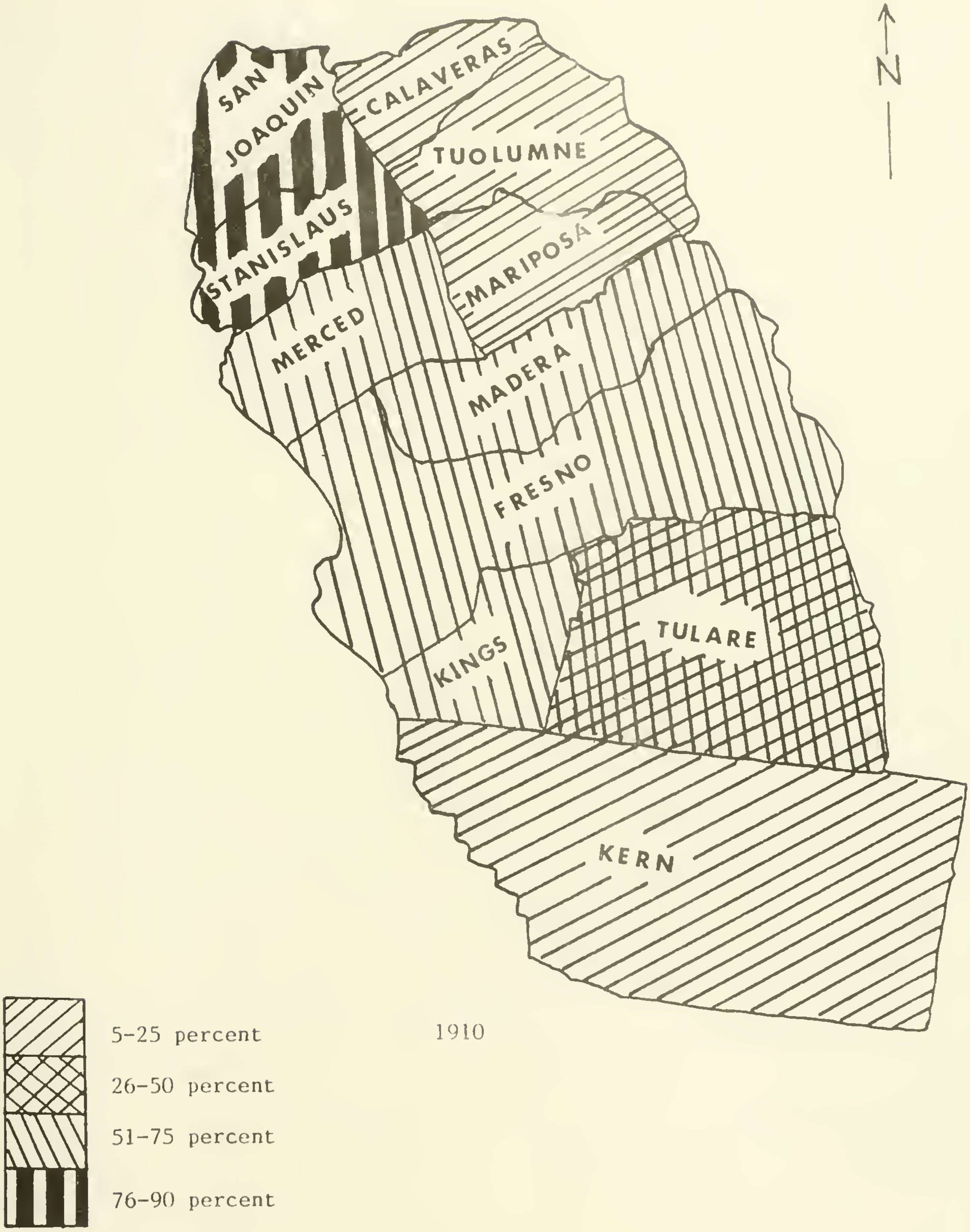

N
SAN JOAQUIN
STANISLAUS
CALAVERAS
TUOLUMNE
MARIPOSA
MERCED
MADERA
FRESNO
KINGS
TULARE
KERN
5-25 percent
26-50 percent
51-75 percent
76-90 percent
1910

Figure 19F

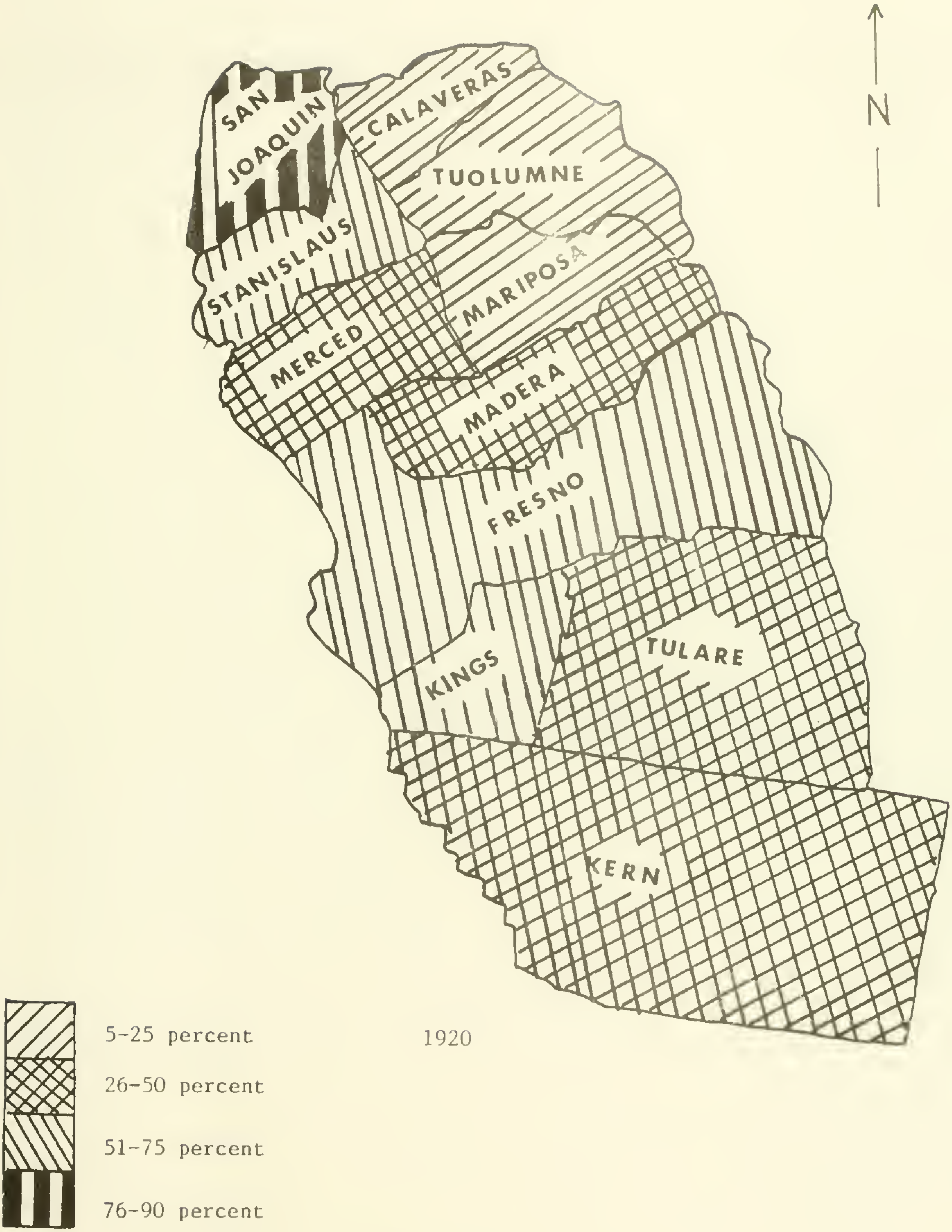

N
SAN JOAQUIN
CALAVERAS
TUOLUMNE
STANISLAUS
MARIPOSA
MERCED
MADERA
FRESNO
TULARE
KINGS
KERN
1920
5-25 percent
26-50 percent
51-75 percent
76-90 percent

Figure 19G

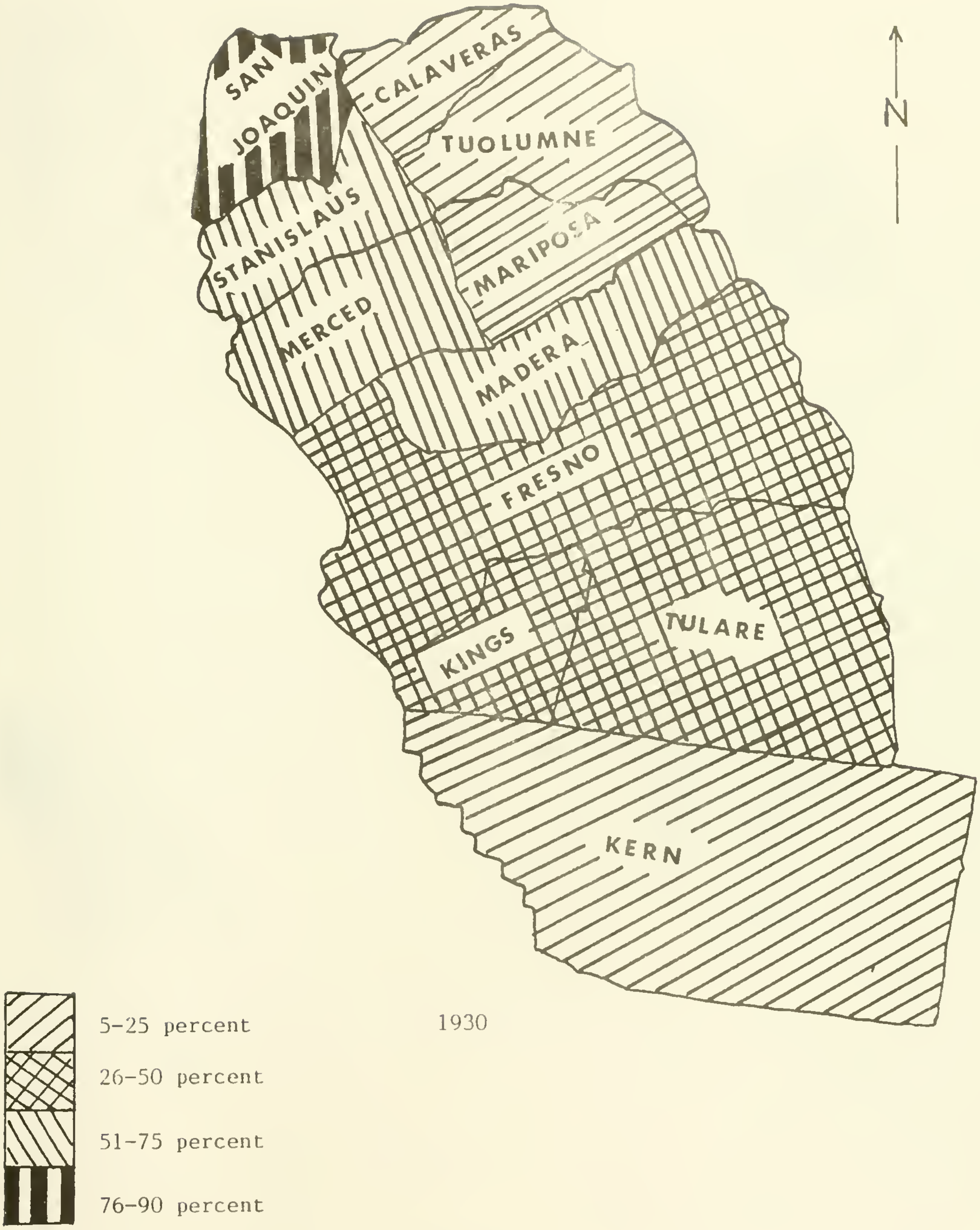
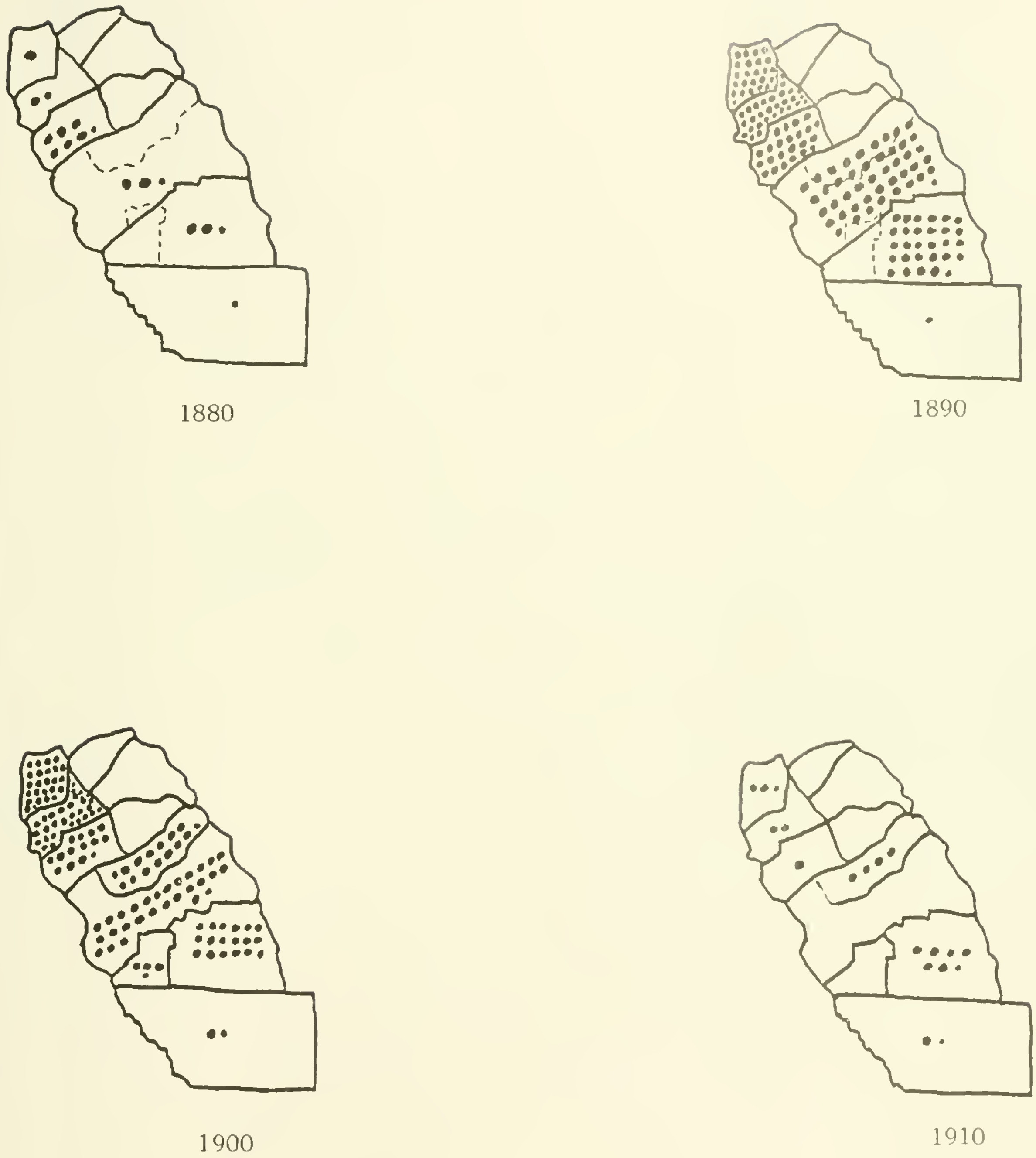

SAN
JOAQUIN
CALAVERAS
TUOLUMNE
STANISLAUS
MARIPOSA
MERCED
MADERA
FRESNO
KINGS
TULARE
KERN
N
5-25 percent
26-50 percent
51-75 percent
76-90 percent
1930

Figure 19H

CENTERS OF PRODUCTION--WHEAT
SAN JOAQUIN VALLEY, 1880-1930

(1 dot equals 10,000 acres)



From U.S. Census

Figure 20A

1920

1930

Figure 20B

CENTERS OF PRODUCTION--BARLEY
SAN JOAQUIN VALLEY, 1880-1930

(1 dot equals 10,000 acres)

1880

1890

1900

1910

From U.S. Census

Figure 21A

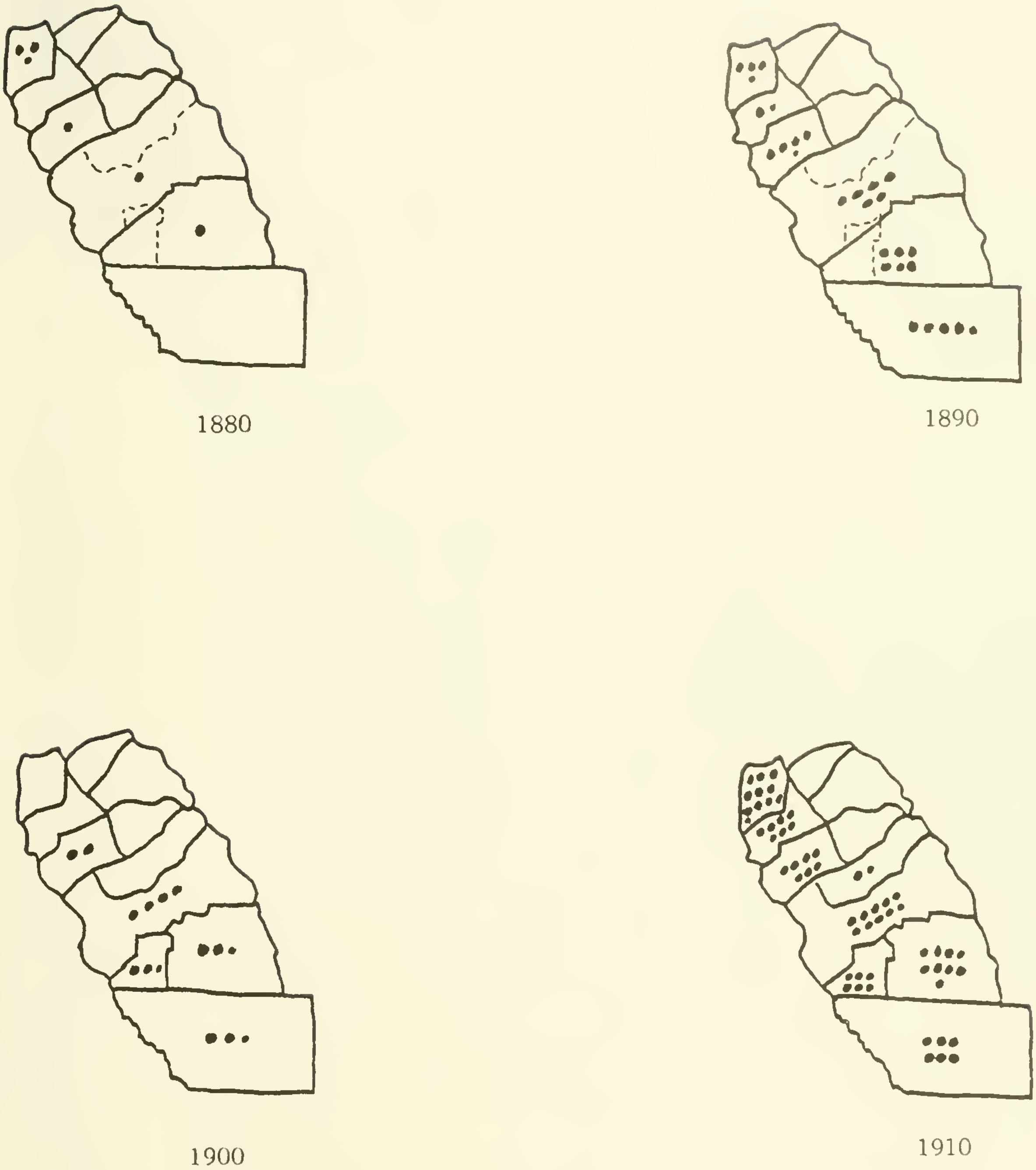
1920

1930

Figure 21B

CENTERS OF PRODUCTION-HAY
SAN JOAQUIN VALLEY, 1880-1930

(Each dot, 10,000 acres mown hay)



From U.S. Census

Figure 22A

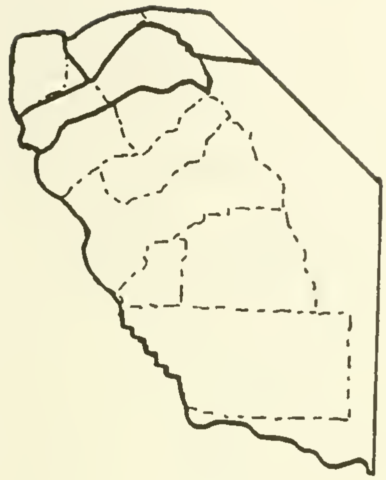
1920

1930

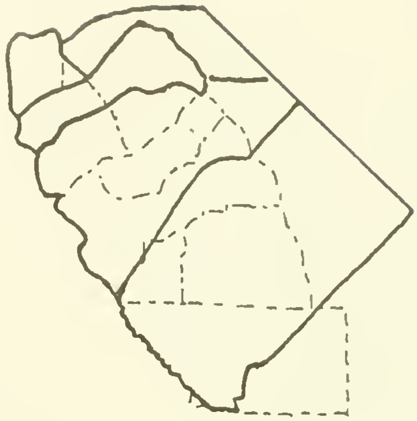
Figure 22B

CENTERS OF PRODUCTION--CATTLE,
SAN JOAQUIN VALLEY, 1850-1930

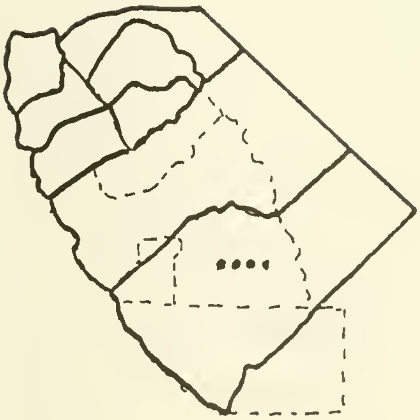
(1 dot equals 10,000 head)



1850



1852



1860

1870

From U.S. Census

Figure 23A

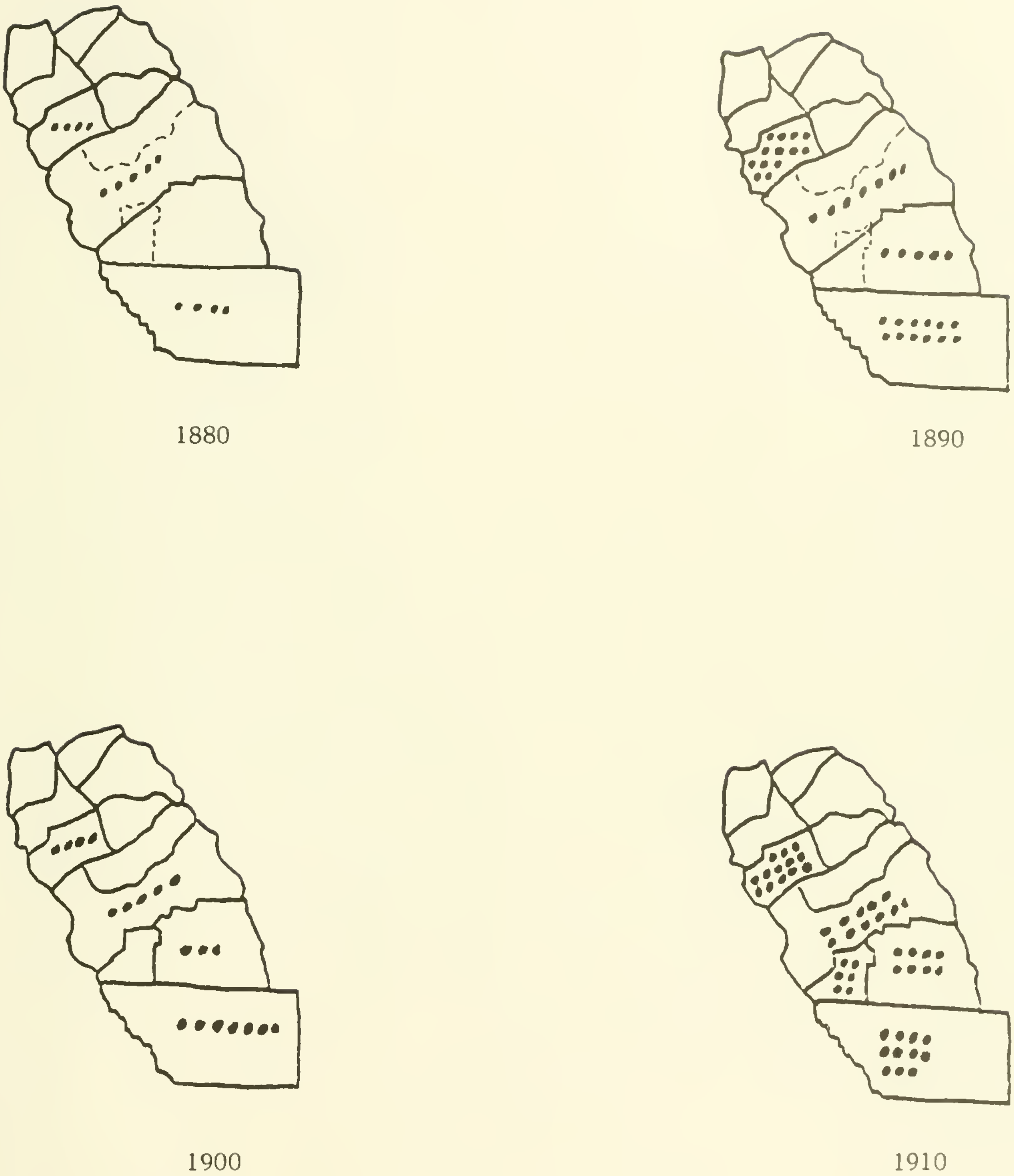


Figure 23B

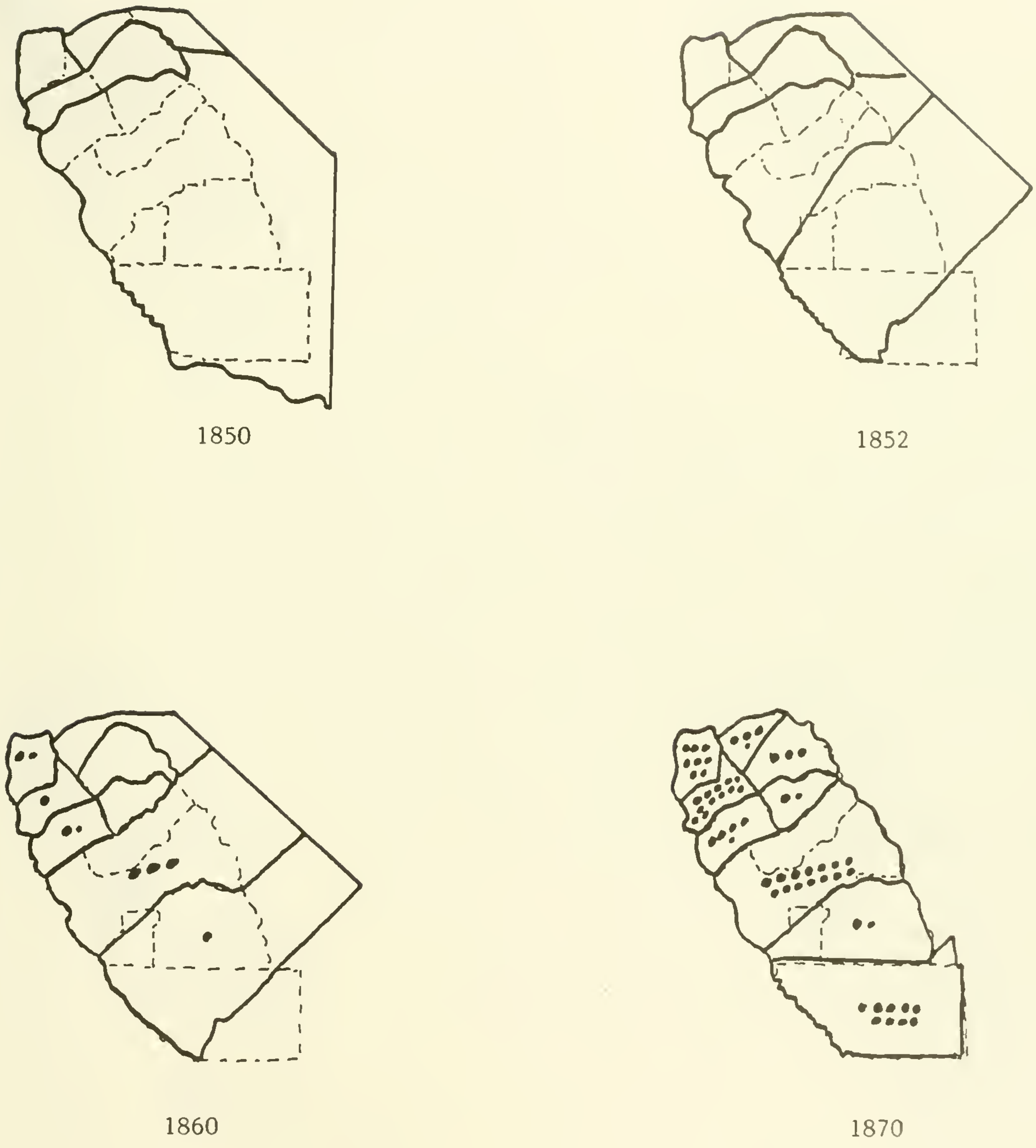
1920

1930

Figure 23C

CENTERS OF PRODUCTION--SHEEP,
SAN JOAQUIN VALLEY, 1850-1930

(1 dot equals 10,000 head)



From U.S. Census

Figure 24A

1880

1890

1900

1910

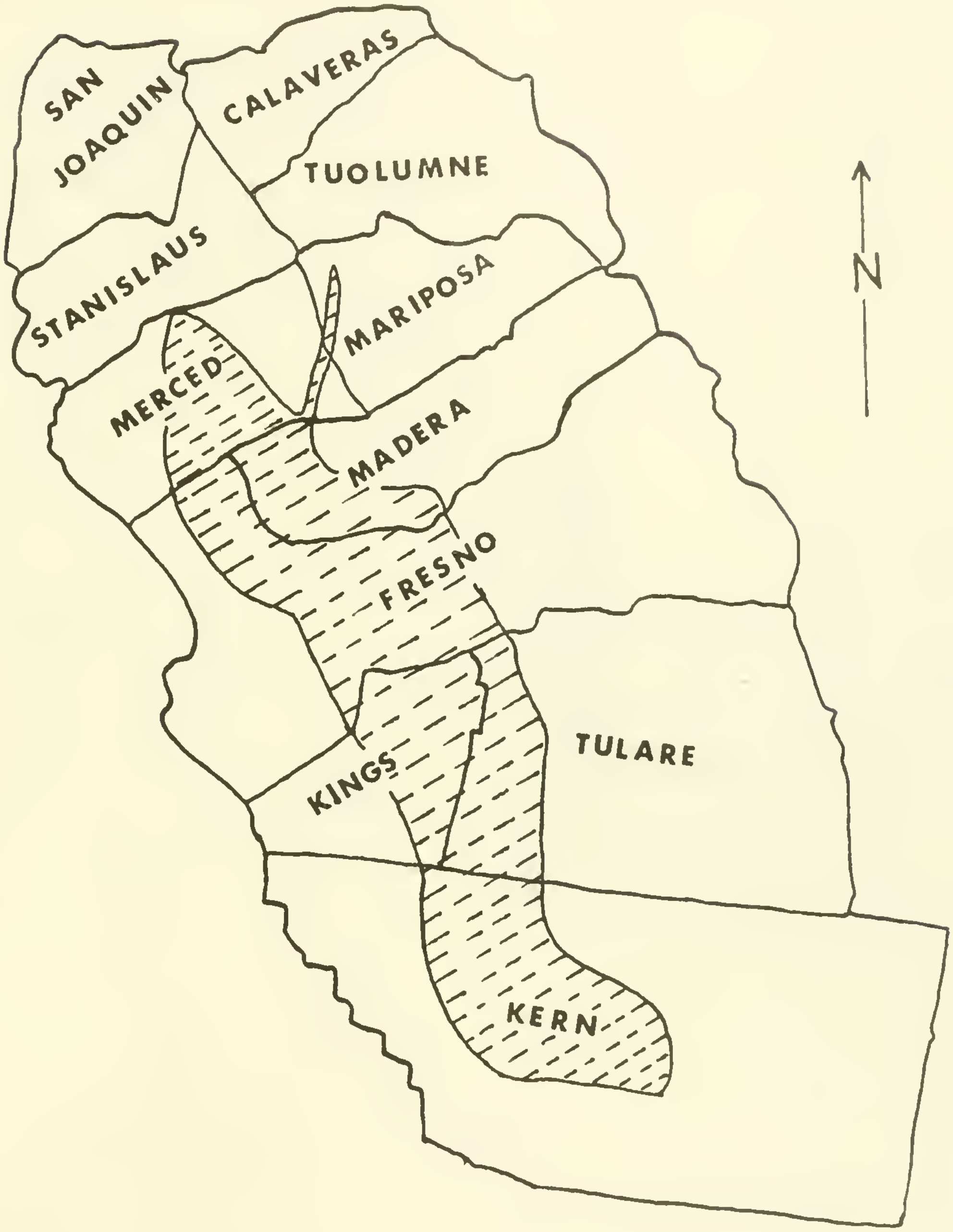
Figure 24B

1920

1930

Figure 24C

APPROXIMATE LOCATION COTTON
PRODUCTION, SAN JOAQUIN
VALLEY, mid-1960's



After Durrenberger, 1968

Figure 25A

APPROXIMATE LOCATION, CITRUS FRUIT INDUSTRY, SAN JOAQUIN VALLEY, mid-1960's

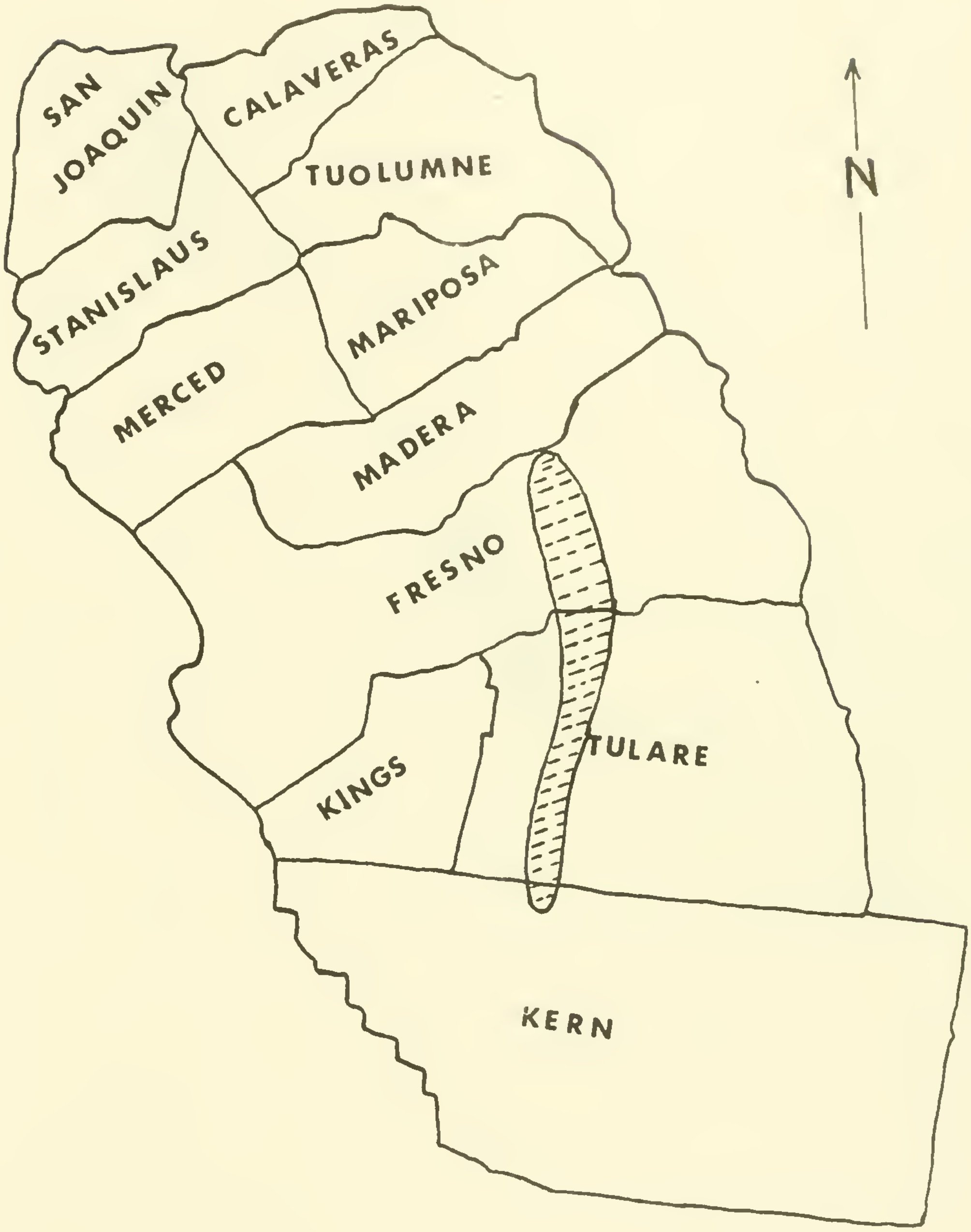


Figure 25B

APPROXIMATE LOCATION, DECIDIOUS
FRUIT INDUSTRY, SAN JOAQUIN
VALLEY, mid-1960's

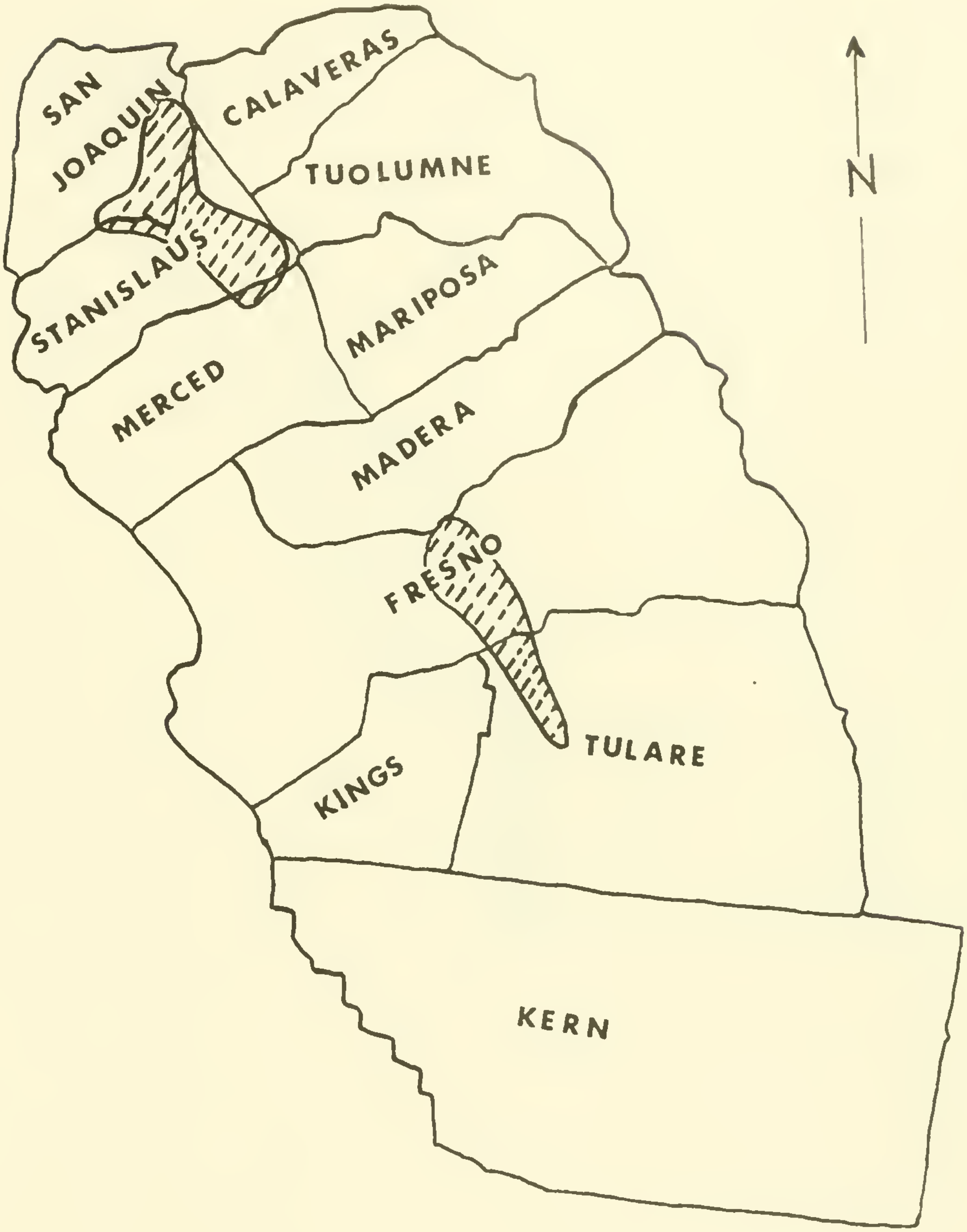


Figure 25C

APPROXIMATE LOCATION, GRAPE
INDUSTRY, SAN JOAQUIN
VALLEY, mid-1960's

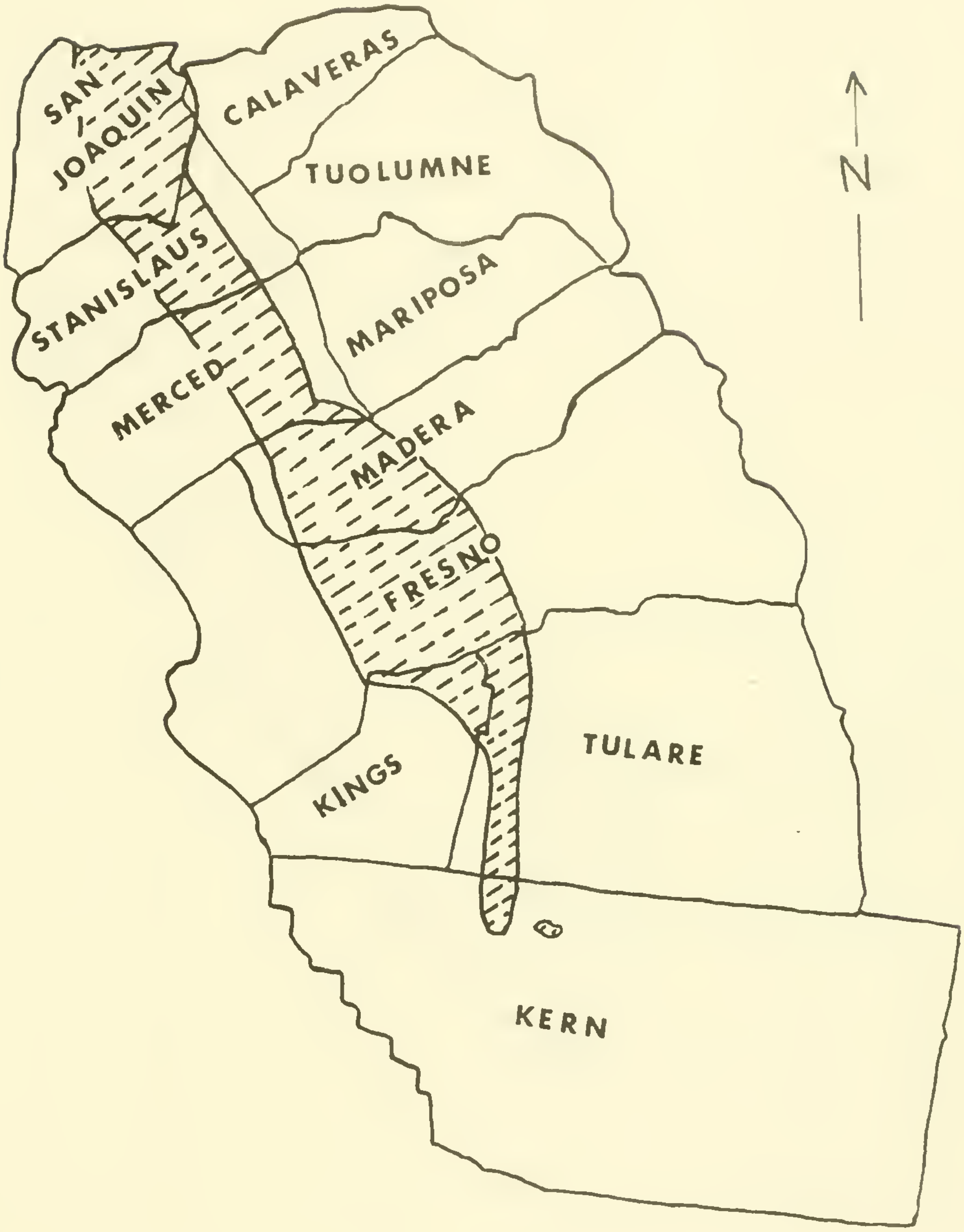
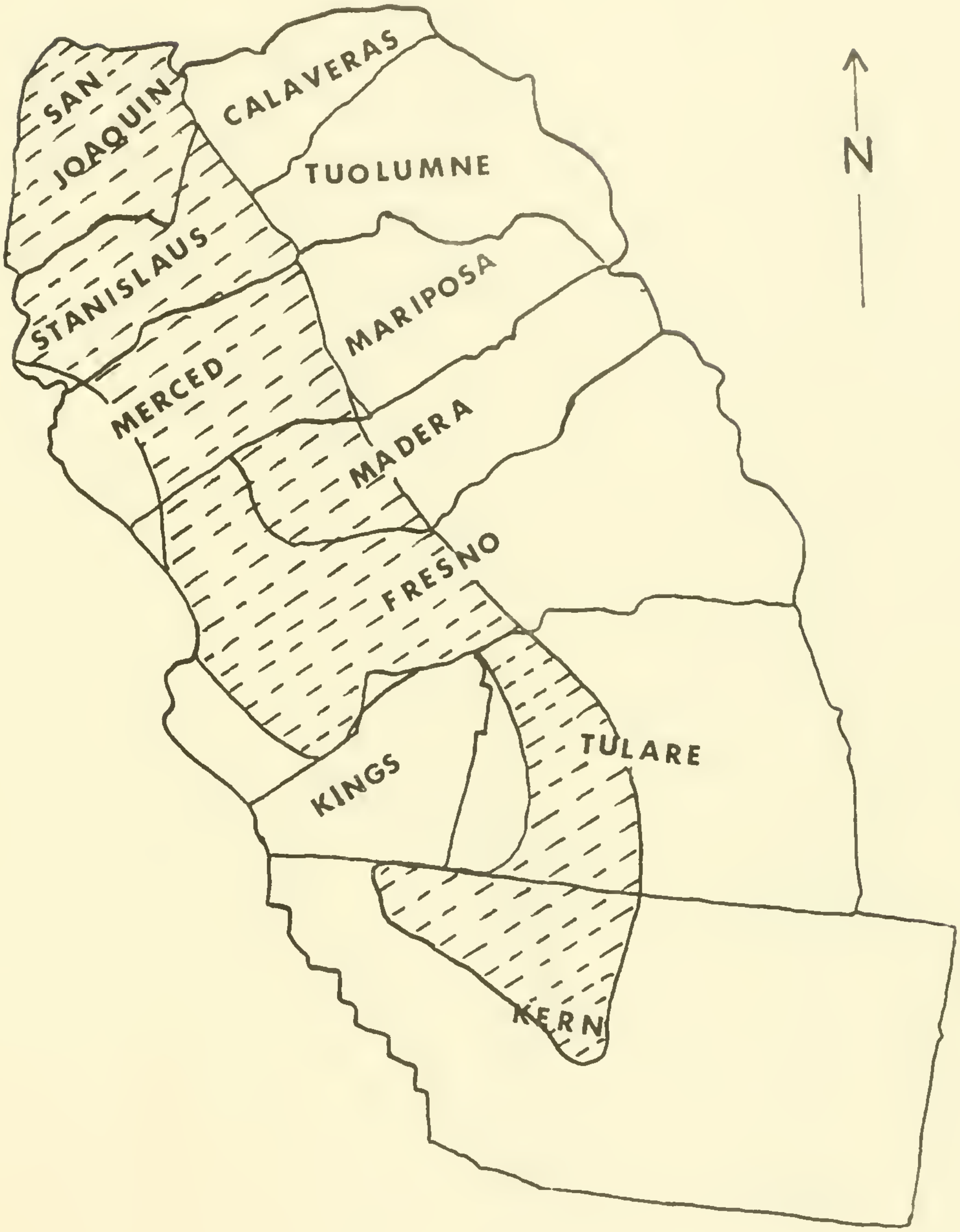


Figure 25D

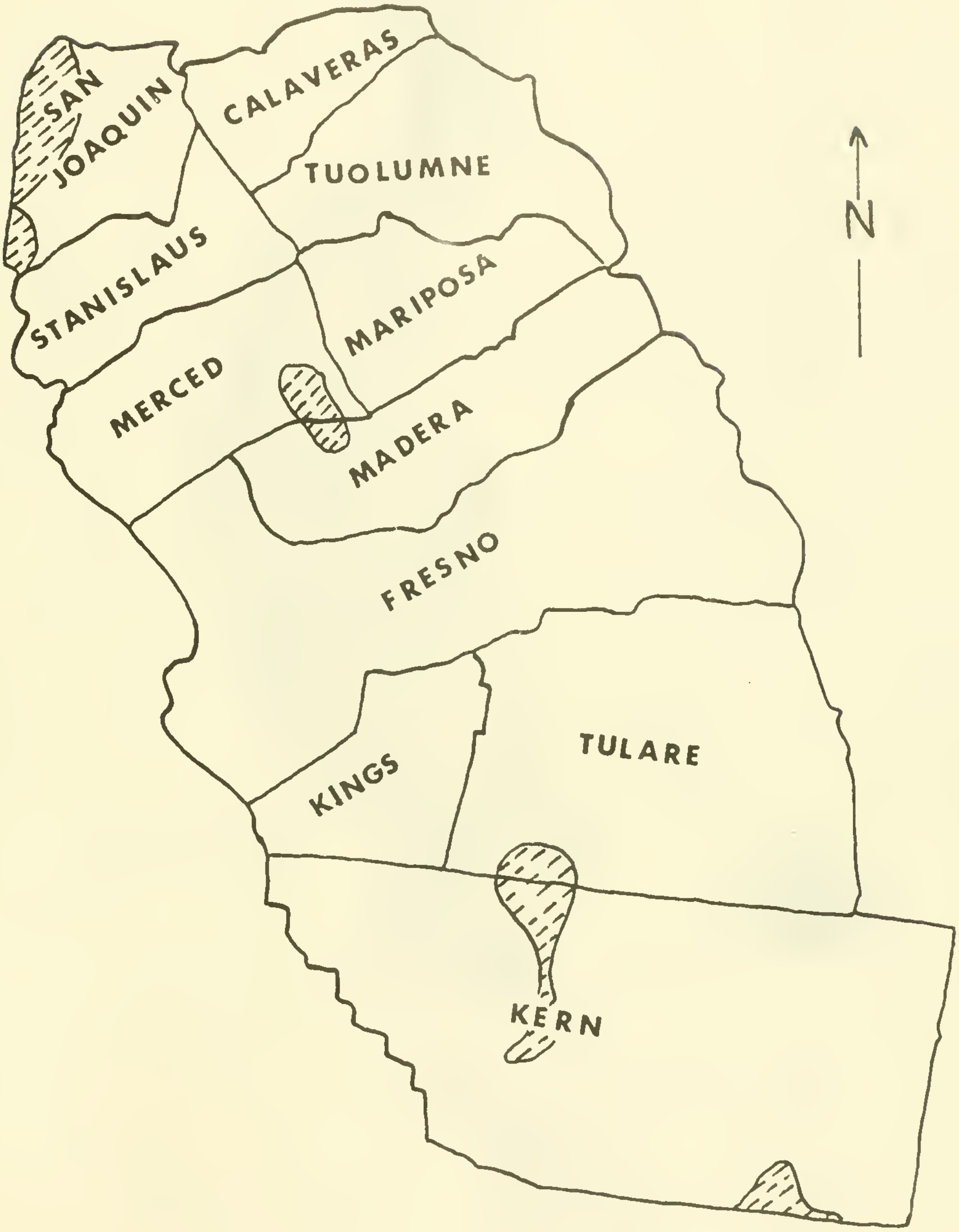
APPROXIMATE LOCATION, ALFALFA PRODUCTION, SAN JOAQUIN VALLEY, mid-1960's



After Durrenberger, 1968

Figure 25E

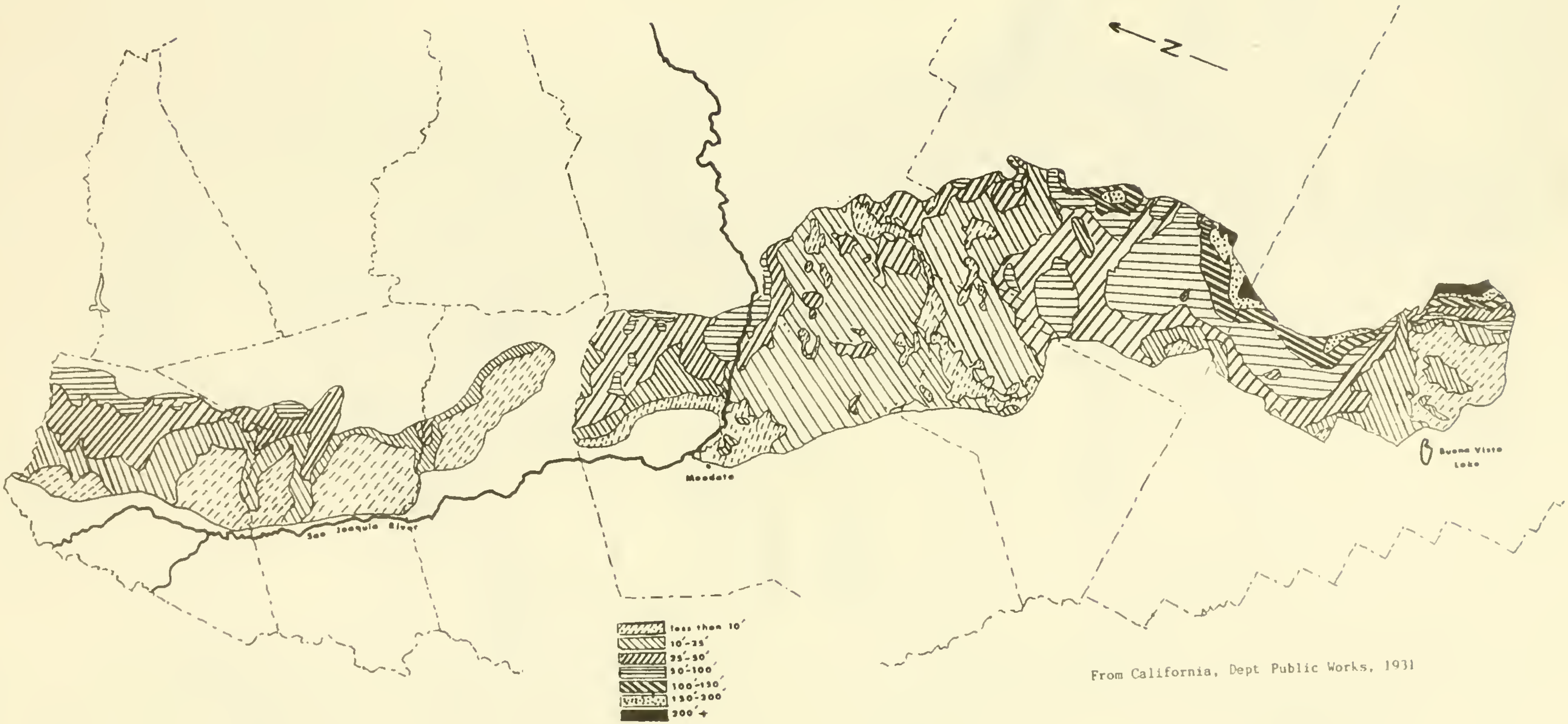
APPROXIMATE LOCATION, VEGETABLE
PRODUCTION, SAN JOAQUIN
VALLEY, mid-1960's



After Durrenberger, 1968

Figure 25F

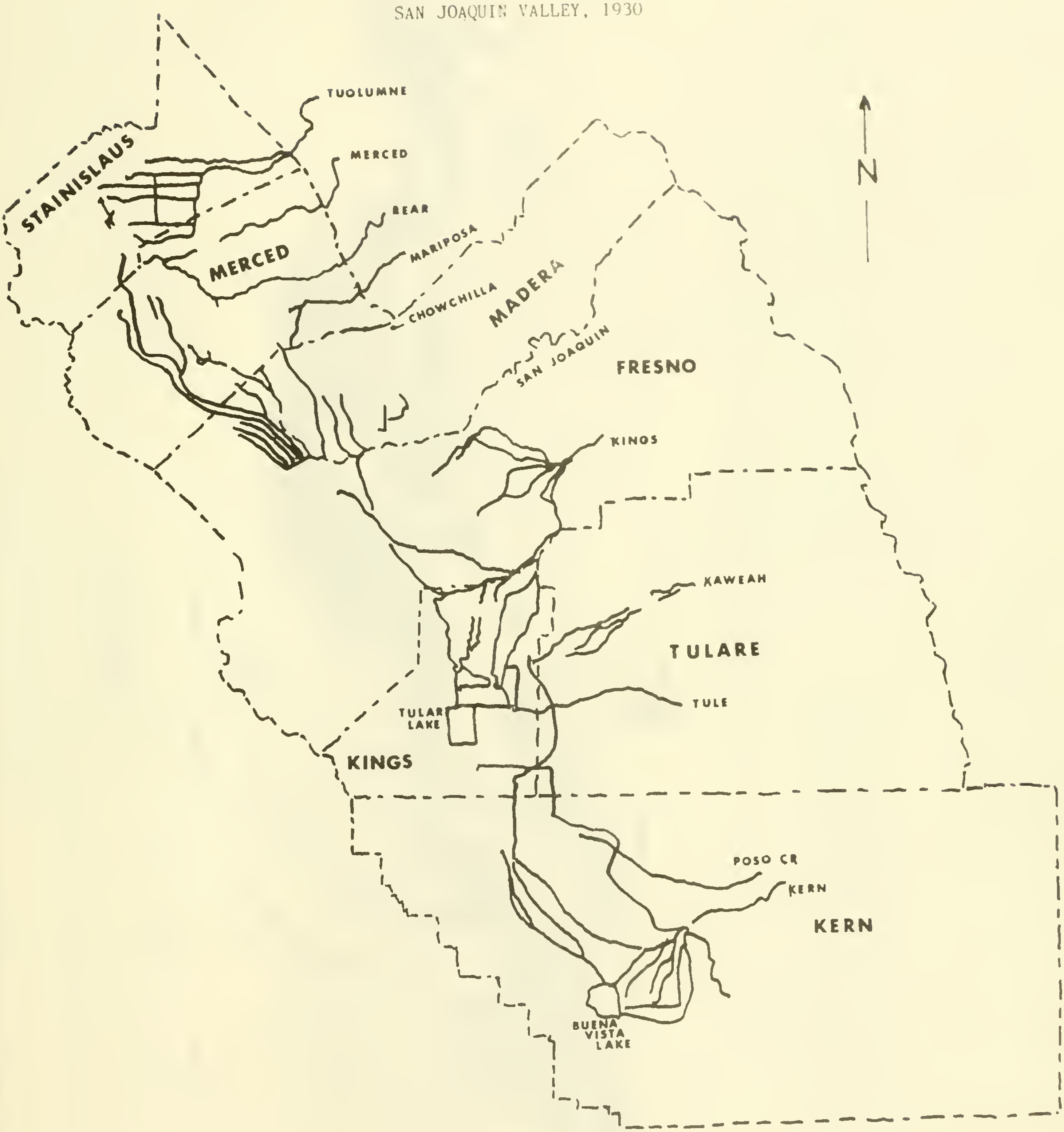
DEPTHS TO GROUNDWATER, SAN JOAQUIN VALLEY, FALL, 1929



From California, Dept Public Works, 1931

Figure 26

MAJOR IRRIGATION SYSTEMS
SAN JOAQUIN VALLEY, 1930



From Beck and Haase, 1974

Figure 27

IRRIGATED LANDS, SAN
JOAQUIN VALLEY, 1930

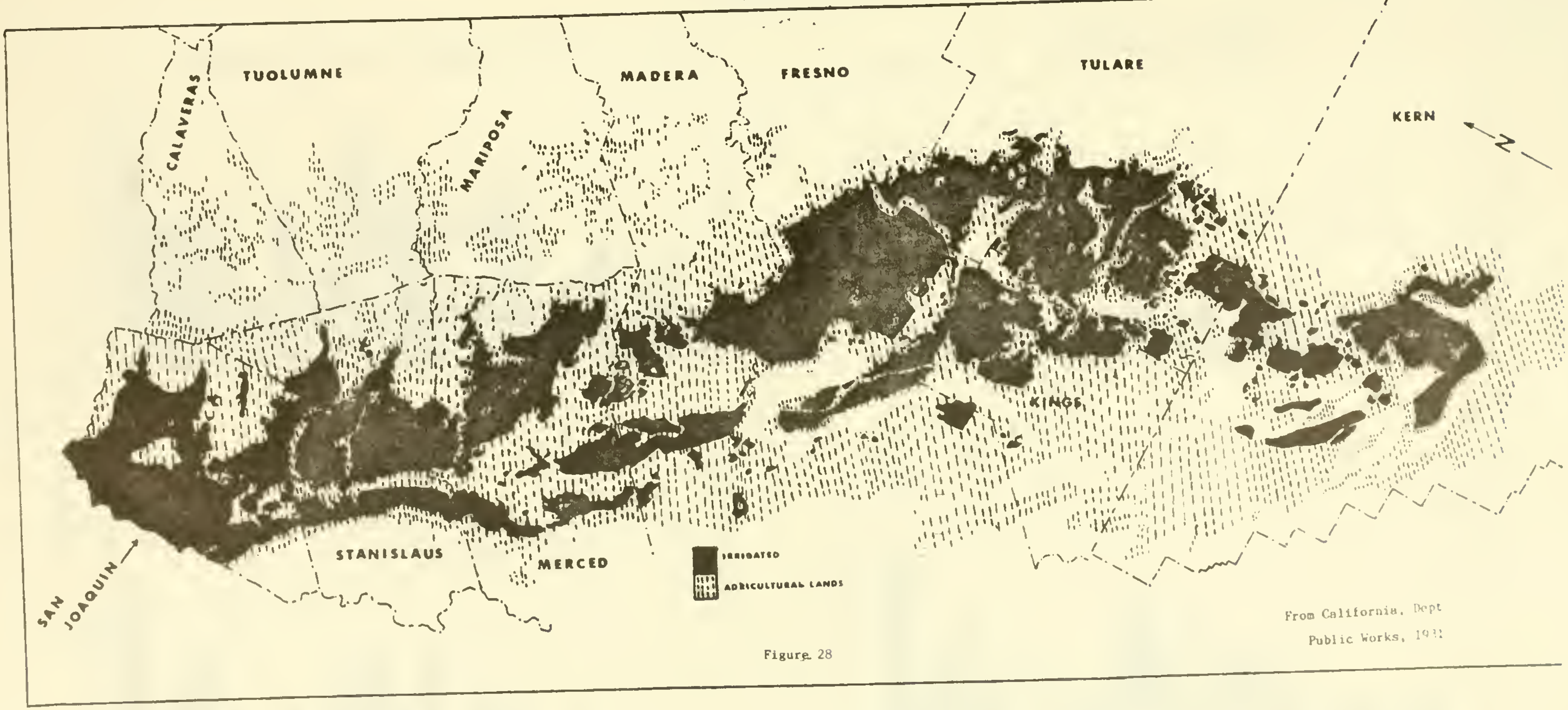
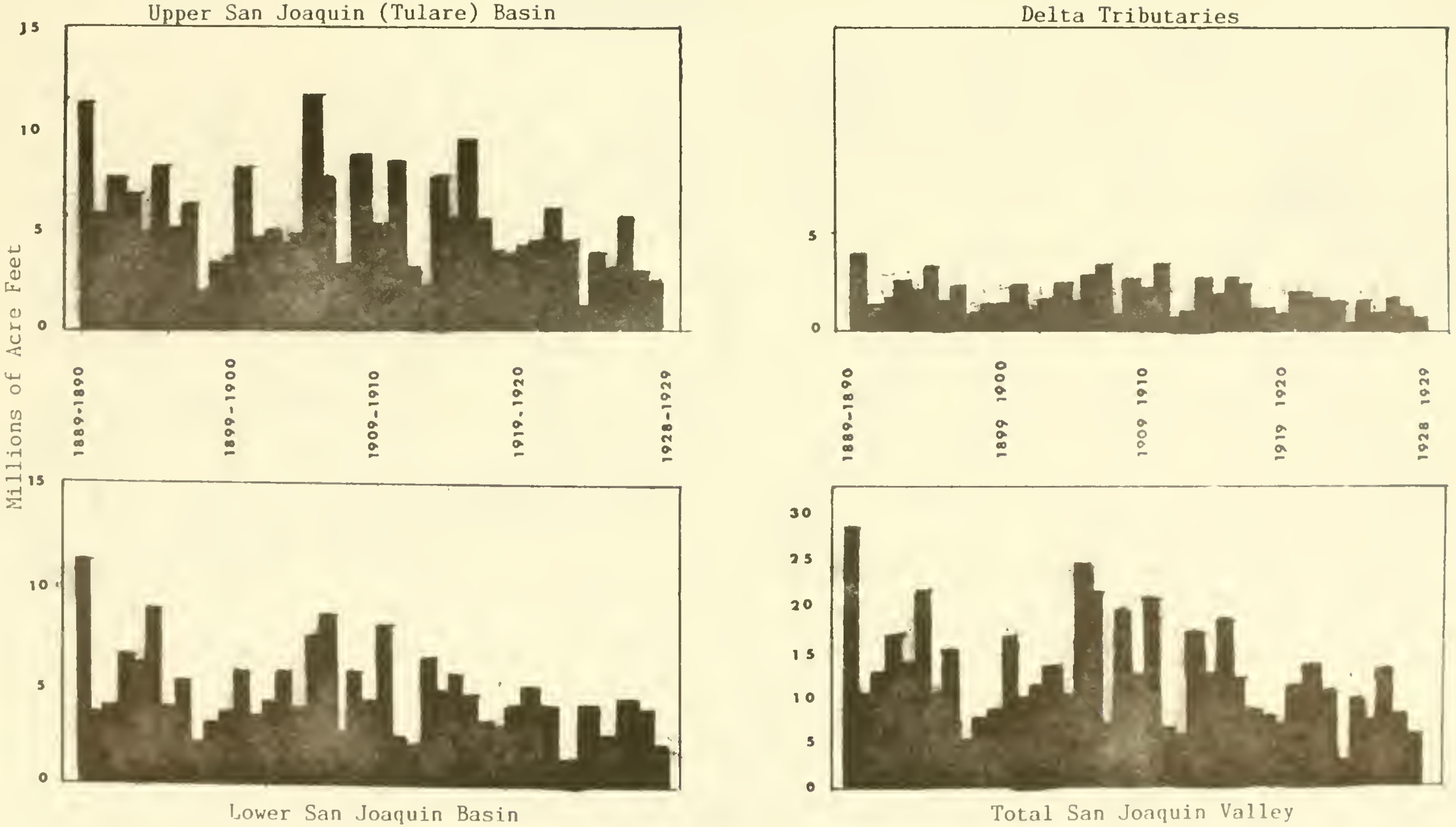


Figure 28

From California, Dept
Public Works, [illegible]

ANNUAL UNIMPARED RUNOFF BY
STREAM GROUPS, SAN JOAQUIN
VALLEY, CALIFORNIA



From California, Dept. Public Works, 1931

Figure 29

STREAMS AND RESERVOIRS, SAN
JOAQUIN VALLEY, 1930

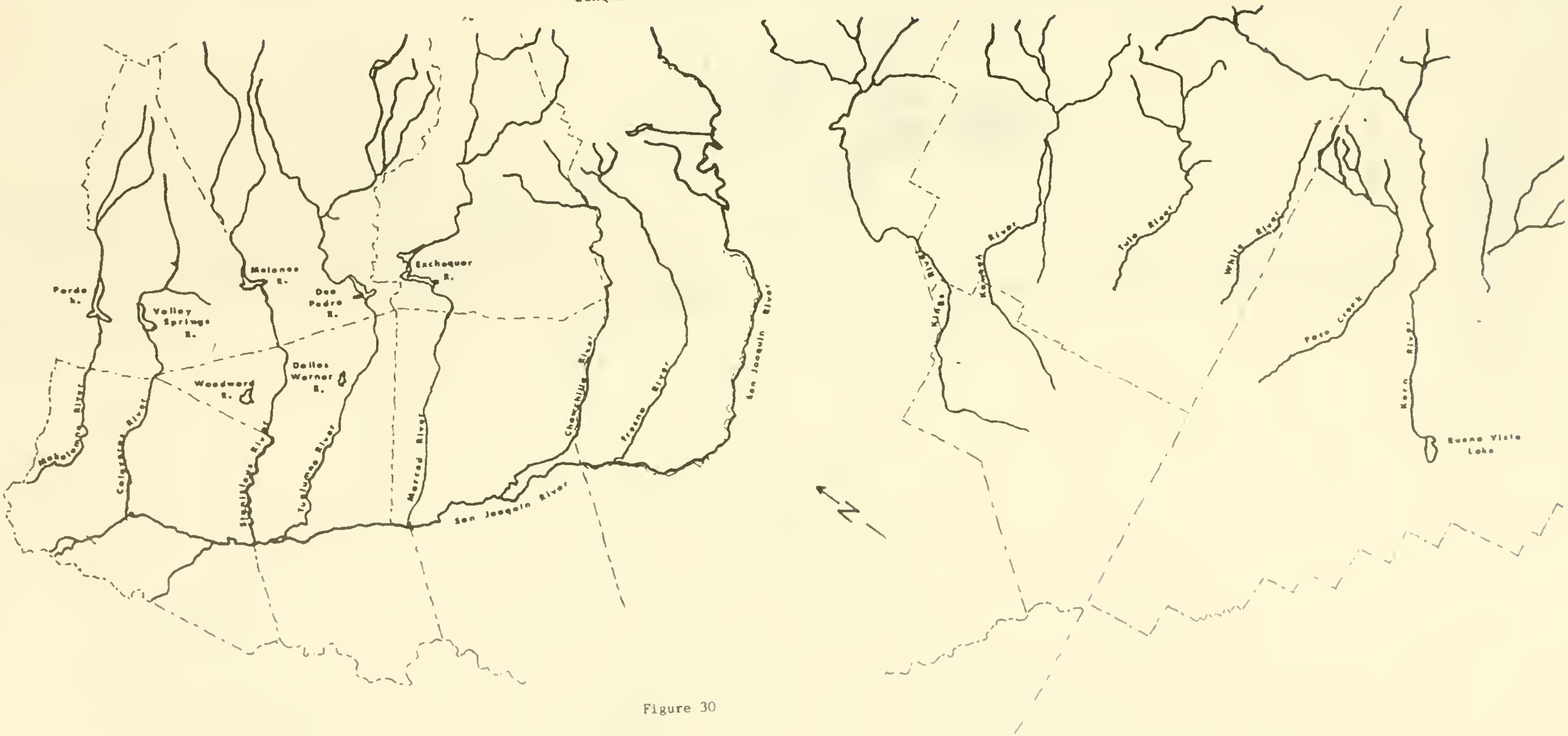


Figure 30

APPROXIMATE LOCATION OF LAND
IN DRAINAGE ENTERPRISES,
CALIFORNIA, 1920

From U.S. Census, 1922

Figure 31A

APPROXIMATE LOCATION OF LAND
IN DRAINAGE ENTERPRISES,
CALIFORNIA, 1930

From U.S. Census, 1932

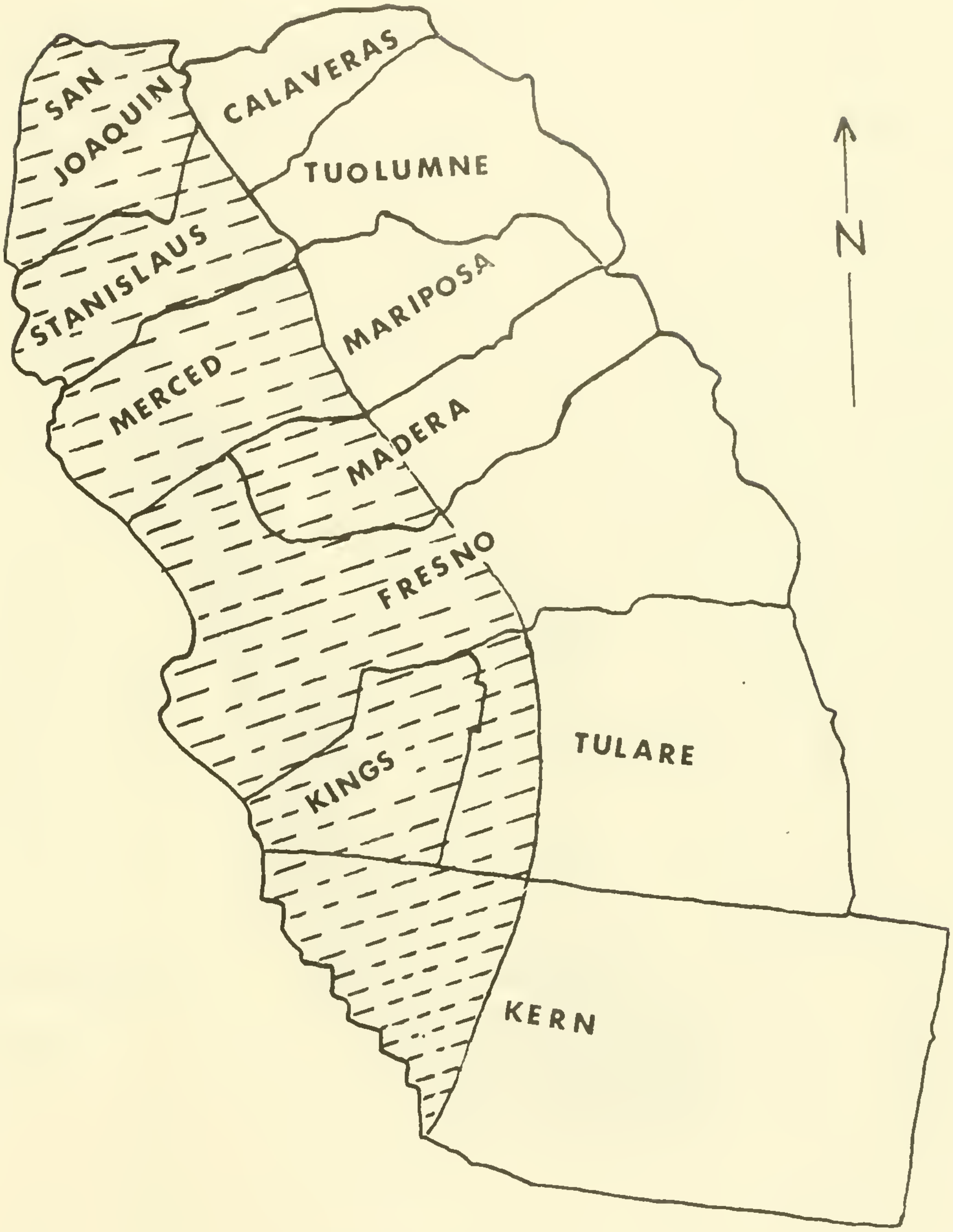
Figure 31B

ANCESTRAL RANGE, PRONGHORN
ANTELOPE, SAN JOAQUIN VALLEY

From Beck and Haase, 1974

Figure 32

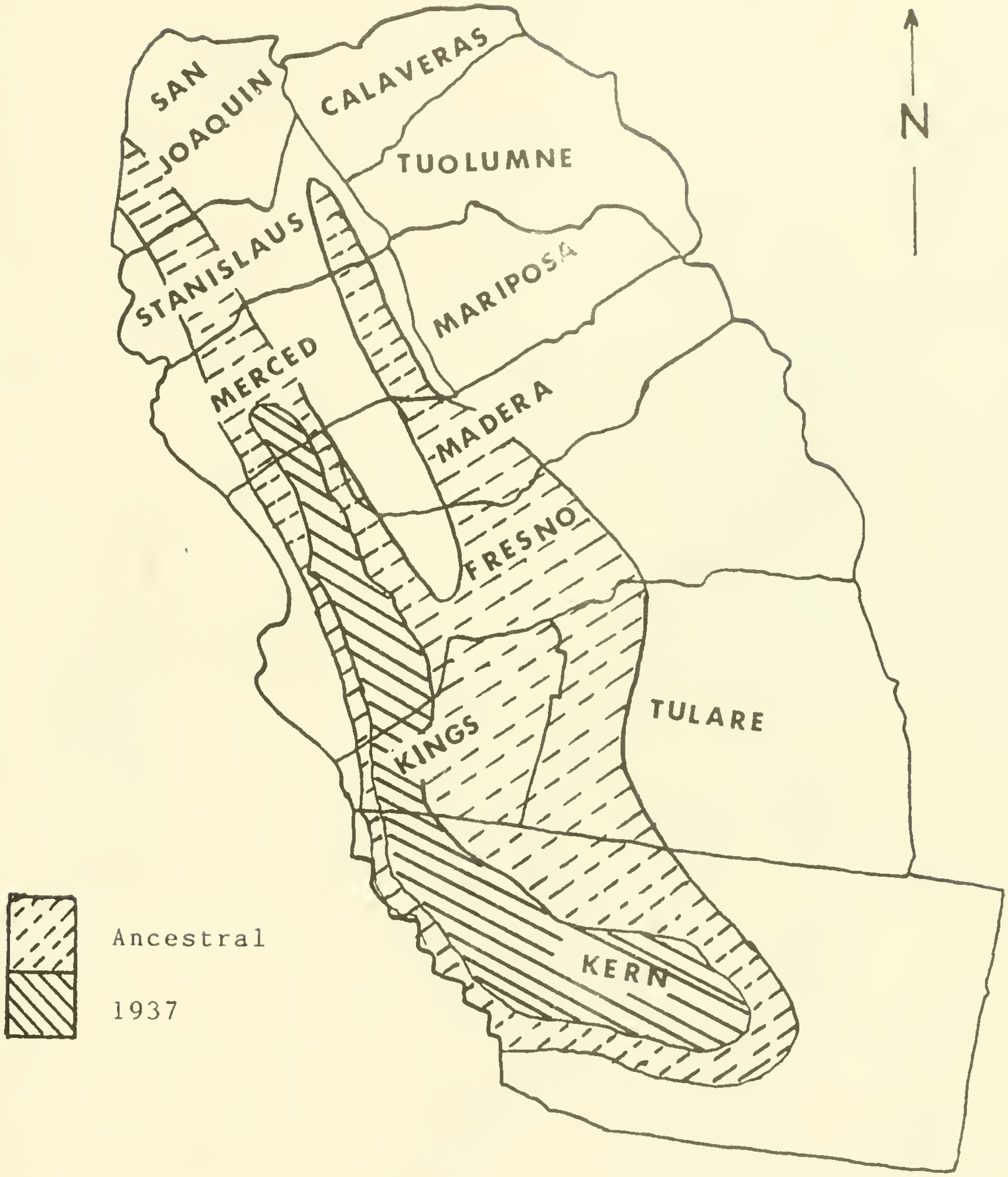
ANCESTRAL RANGE, TULE ELK,
SAN JOAQUIN VALLEY



From Beck and Haase, 1974

Figure 33

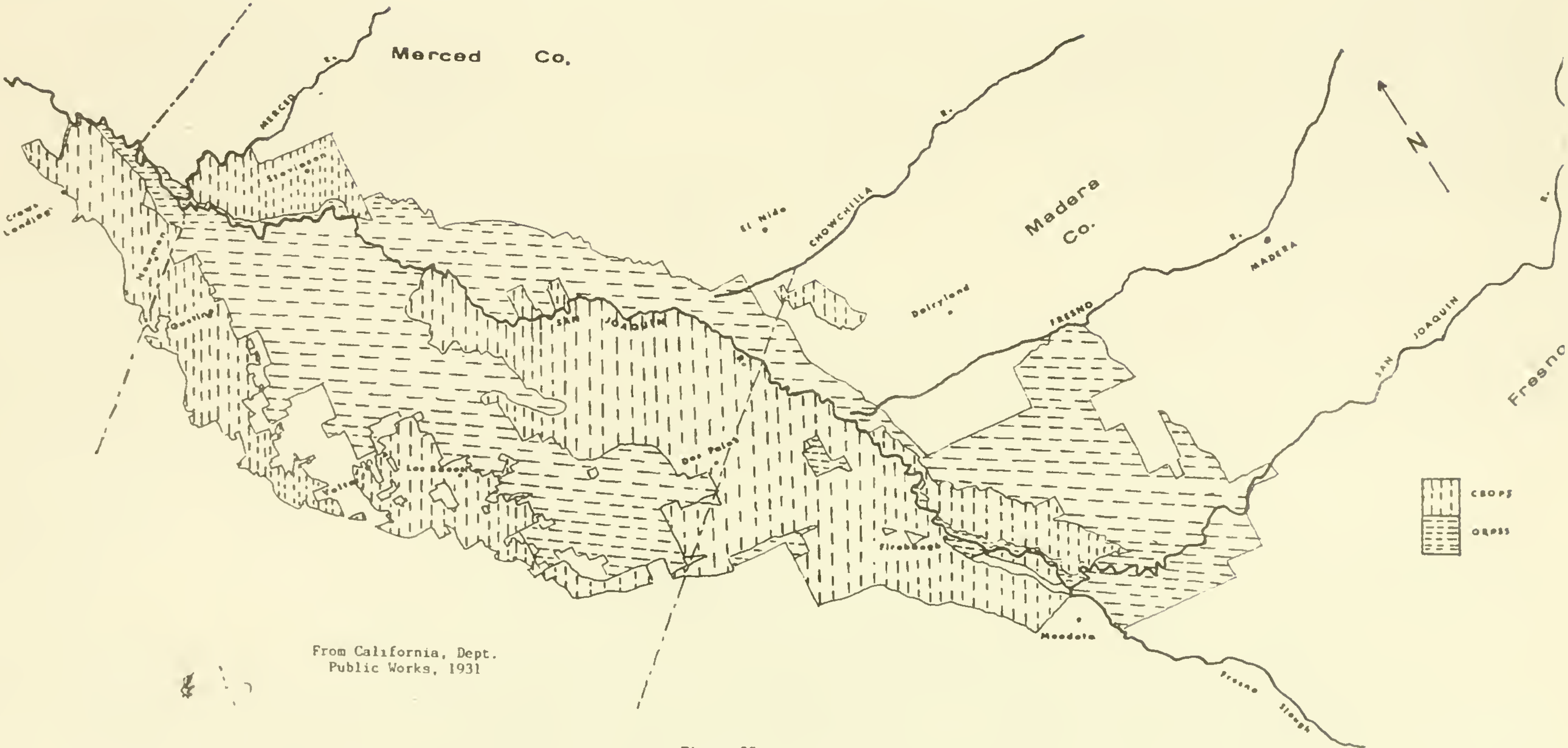
RANGE OF KIT FOX:
ANCESTRAL AND 1937,
SAN JOAQUIN VALLEY



From Grinnell, et al, 1937

Figure 34

LANDS IRRIGATED FROM SAN
JOAQUIN RIVER: FRESNO SLOUGH
TO CROWS LANDING, 1930



From California, Dept.
Public Works, 1931

Figure 35