

State of California  
THE RESOURCES AGENCY  
Department of Fish and Game

POPULATION STATUS OF THE  
RIPARIAN BRUSH RABBIT  
(*Sylvilagus bachmani riparius*)

by

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Wildlife Management Division, Nongame Bird and Mammal Section  
Contract Final Report  
31 December 1986

Cover Photograph by Glenn E. Basey

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ABSTRACT

The historical distribution of the Riparian Brush Rabbit (*Sylvilagus bachmani riparius*) was probably within riparian communities in the floodplains of the Merced, Stanislaus, Tuolumne, and San Joaquin rivers in Merced, Stanislaus, and San Joaquin counties. Remaining natural communities in these areas were inventoried for presence of the Riparian Brush Rabbit and assessed for their suitability as habitat. Twelve sites were trapped for three-day periods. Only Desert Cottontails (*S. audubonii*) were captured. Riparian Brush Rabbits were found only in Caswell Memorial State Park (MSP), San Joaquin County, along the Stanislaus River. Comparison of characteristics of the plant communities were made at 10 sites occupied by Riparian Brush Rabbits with 10 sites outside the park occupied by Desert Cottontails and 10 sites unoccupied by rabbits. Sites occupied by Riparian Brush Rabbits had significantly fewer willows (*Salix* spp.) in both the understory and canopy than other sites, more ground litter than sites occupied by Desert Cottontails, and a higher area of roses (*Rosa californica*) than sites unoccupied by either species. These differences indicate that sites not inhabited by Riparian Brush Rabbits are subjected to greater flooding and represent earlier successional stages. A few areas along the Merced, San Joaquin, and Stanislaus rivers offer limited potential to support reintroduced populations of Riparian Brush Rabbits, but require modifications to provide suitable habitat and refuge from floods. Information was obtained indicating that Riparian Brush Rabbits sometimes shelter from floods by climbing trees. The only other available refuge from floods is on the levee bordering the river. Current maintenance practices keep levees nearly free of plants, denying Riparian Brush Rabbits refuges with cover and food to escape from floods. This is considered to be a principal factor in the extirpation of populations of Riparian Brush Rabbits. Recommendations are made for providing safe shelter from floods and modifying present hunting regulations. State and Federal Endangered Species status for the Riparian Brush Rabbit is also recommended.

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<sup>1</sup> Funded by California Endangered Species Tax Checkoff Program.  
Department of Fish and Game, Wildlife Management Division, Nongame Bird  
and Mammal Section, Contract Final Report, 31 December 1986.

## RECOMMENDATIONS

1. Propose to the California Fish and Game Commission and the U.S. Secretary of the Interior that the Riparian Brush Rabbit (*Sylvilagus bachmani riparius*) be classified as an Endangered Species.
2. In conjunction with a program to reestablish Riparian Brush Rabbit populations on various sites throughout their historical range, propose to the California Fish and Game Commission that hunting for all rabbits and hares be prohibited within the historical range of the Riparian Brush Rabbit, within the flood levees of the Stanislaus River from Caswell Memorial State Park (MSP) to the mouth of the Stanislaus River, and within the flood levees of the San Joaquin River and Christman Island from the confluence of the Tuolumne River to the Stanislaus River.
3. Develop procedures in consultation with the Army Corps of Engineers, California Department of Fish and Game, and other involved state and local agencies for the modification of levee maintenance practices with the objective of making levees suitable refugia for Riparian Brush Rabbits during floods.
4. Develop and implement a plan, in consultation with the Army Corps of Engineers, Department of Fish and Game, California Department of Parks and Recreation, and other involved governmental agencies to enhance and expand habitat and Riparian Brush Rabbit access to areas that can be used to escape from floods in and around Caswell MSP.
5. In consultation with the U.S. Fish and Wildlife Service, National Audubon Society, Department of Fish and Game, and other involved parties, include habitat needs of Riparian Brush Rabbits in the evaluation of key habitats for parcels assessed for inclusion in any public or private refuges within the historical range of the Riparian Brush Rabbit.

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## INTRODUCTION

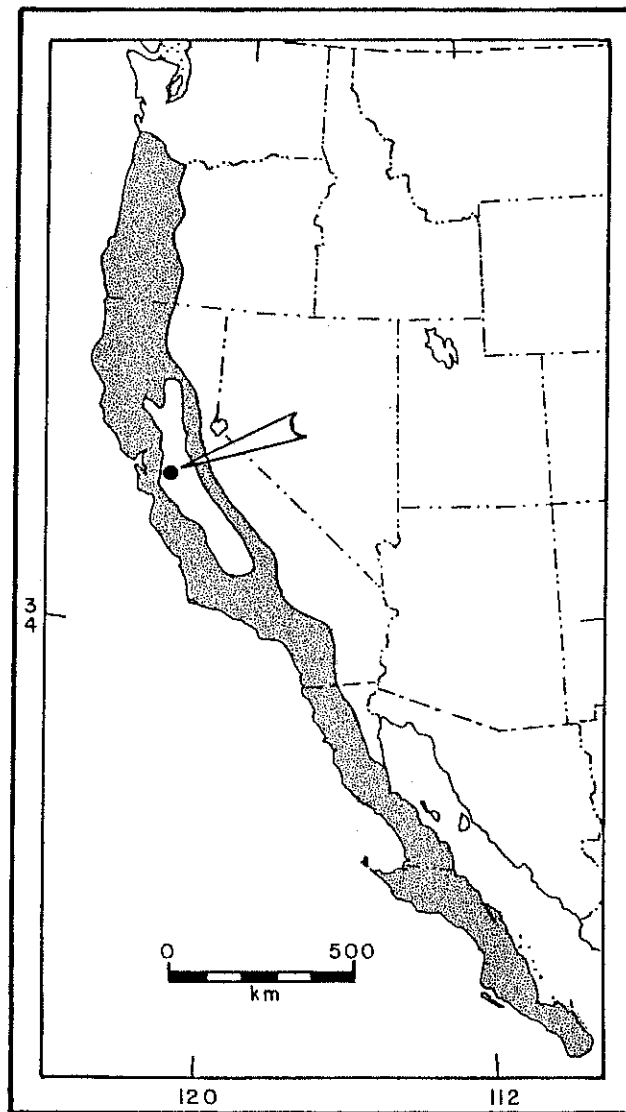
The geographic range of the Brush Rabbit (*Sylvilagus bachmani*) extends along the Pacific Coast of North America from the Columbia River on the north to the Cape region of Baja California Sur (Fig. 1). The Pacific slopes of the Cascade, Sierra Nevada, and southern California ranges form the eastern boundary of its range on the north; on the south, it is found at scattered sites along both coasts on the Baja California peninsula (Hall 1981). The Riparian Brush Rabbit, *S. b. riparius* (Fig. 2), is known from three sites in a small area in the northern San Joaquin Valley, California, in riparian communities along the lower portions of the San Joaquin and Stanislaus rivers (Fig. 2; Orr 1940, Williams 1986).

Throughout their range, habitat for Brush Rabbits consists of dense shrubs; they rarely venture more than a meter or two from dense cover (Chapman 1974, Orr 1940). Brush Rabbits use relatively small areas compared to other cottontails. Size and shape of home ranges were found to conform to size and shape of clumps of shrubs, and clumps smaller than about 460 m<sup>2</sup> were uninhabited (Chapman 1971). Brush Rabbits displaced from 16 to 350 m returned to their home areas, but Chapman (1971) noted that homing time increased logarithmically with increasing distances of displacement. Chapman (1974) remarked that Brush Rabbits could not home from distances as great as those reported for other small mammals.

Food for Brush Rabbits includes a wide variety of leaves, stems, and roots of herbaceous and woody plants; Orr (1940) considered grasses to be the most important food for Brush Rabbits, but shrubs such as California wild rose (*Rosa californica*), Douglas' coyote bush (*Baccharis douglasii*), and Pacific blackberry (*Rubus vitifolius*) were also eaten. When available, green clover (*Trifolium involucreatum*) was preferred over all other foods.

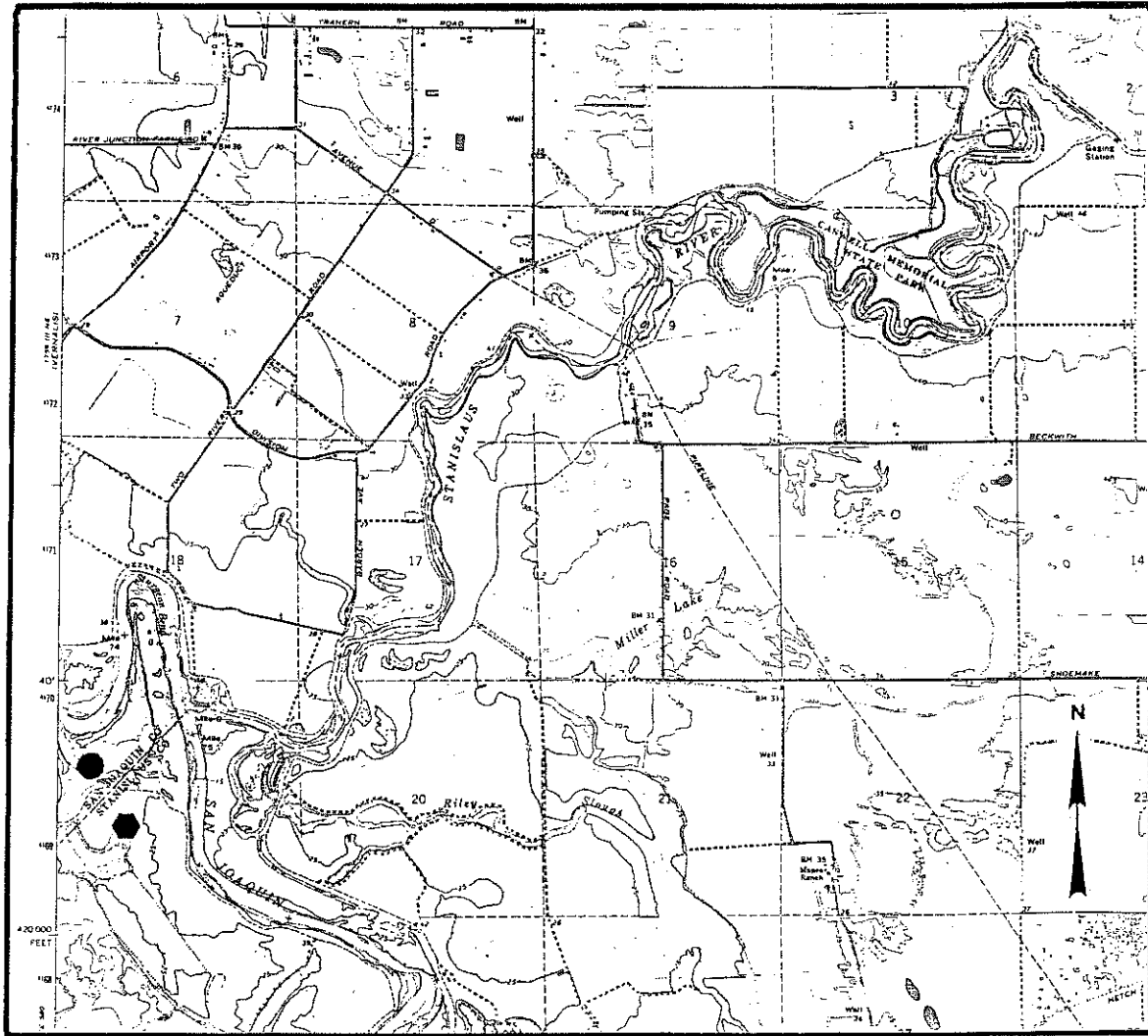
The breeding season for Brush Rabbits in California extends from about December through May or June (Mossman 1955). Chapman (1974) reported that three litters per reproductive season were likely. Mean litter size probably varies from about three to four in northern and central California (Mossman 1955, Orr 1940). It takes about 4 to 5 months for Brush Rabbits to mature. Brush Rabbits probably do not breed until the winter following their birth. Chapman and Harman (1972) stated that *S. bachmani* was not as fecund as other species of cottontail rabbits.

Prior to widespread modification of streams and reduction of riparian communities by over 90% (Katibah 1984), Brush Rabbits probably ranged along most of the streams flowing onto the floor of the San Joaquin Valley, wherever refuges provided cover above flood levels, although there are few documented records (Williams and Kilburn 1984). Orr (1935) believed that the range of the Riparian Brush Rabbit extended along the San Joaquin River, from Stanislaus County to the Delta region, although records of specimens and sightings were then known only from along the San Joaquin River near the boundary of San Joaquin and Stanislaus counties (Fig. 2). Habitat for *S. b. riparius* was described by Orr (1940) as dense thickets of wild roses, willows (*Salix* spp.), and blackberries growing near the banks of the San Joaquin River. He stated that Riparian Brush Rabbits were never observed in loose brush or open fields.



**Figure 1.** Distribution (shaded area) of the Brush Rabbit (*Sylvilagus bachmani*). Within this broad area, populations inhabit only dense brush and chaparral communities. Location of the Riparian Brush Rabbit (*S. b. riparius*) is indicated by the dot at the end of the arrow. Adapted from Hall (1981).

Since its first discovery by Orr (1935), little additional information on the distribution and biology of *S. b. riparius* has been reported. Williams (1986) summarized unpublished observations on a population under study by Glenn Basey in Caswell Memorial State Park (MSP) along the Stanislaus River, in southern San Joaquin County. The population in Caswell MSP was the only population located between 1971 and 1985, although only the San Joaquin River had been systematically inventoried for presence of Riparian Brush Rabbits (unpubl. data). The size of this population was probably fewer than 100 individuals at the start of



**Figure 2.** Known historic and extant localities of the Riparian Brush Rabbit (*S. b. riparius*). Historic records are: polygon - type locality; circle - sighting recorded by Orr (1935). An extant population is found within Caswell Memorial State Park, San Joaquin County.

the breeding season in November or December (Williams 1986). During winter 1984-85 habitat within the park was reduced by brush clearing and burning undertaken to reduce fuel levels and the threat of wildfires and to enhance control of mosquitoes. Some areas inhabited by Brush Rabbits were cleared and rabbits subsequently disappeared from those sites (G. Basey, unpubl. data). During periodic floods, such as in winters 1979-80, 1982-83, and 1985-86, most of Caswell MSP was under water. The only sites for refuge above flood level may have been on a narrow dike separated in some places by several hundred feet of

cultivated land from areas inhabited by Brush Rabbits. Currently, neither the dike nor the agricultural fields planted to annual crops provide adequate cover for the rabbits.

Outside of Caswell MSP, most of the riparian communities of the lower San Joaquin River and its tributaries, the Merced, Stanislaus, and Tuolumne, are narrow and confined within dikes. Cultivated fields of annual crops, orchards, and vineyards typically extend to the levees, which are kept free of shrubs and most herbaceous plants by periodic applications of herbicides. Within the levees, most areas are narrow and have been at least partly cleared of trees and brush for flood control and to enhance growth of herbaceous plants for livestock. Previous wildlife surveys (e.g., Turlock Lake State Recreation Area, Tuolumne River, Cheryl Johnson, unpubl. data; lower San Joaquin River, Environmental Science Associates [ESA], unpubl. data) failed to locate additional populations of Brush Rabbits in some of the few areas with protected riparian communities.

Upstream between the chaparral communities of the Sierra Nevada foothills and the valley floor, urban and rural home developments, agricultural fields, gold dredging, gravel and sand mining, and dams have collectively destroyed all potential habitat for Brush Rabbits.

The Brush Rabbit is designated a Resident Small Game Species in California. It may be hunted from 1 July through January 30; the daily bag limit is five. Hunting regulations for *S. bachmani*, set by the California Fish and Game Commission, do not distinguish the Riparian Brush Rabbit from other subspecies of *S. bachmani*, and thus it has no special, protected status.

Because of the apparently restricted geographic range of the Riparian Brush Rabbit and the potential to destroy the only known population in Caswell MSP by floods, wild fire, epidemic disease, or other natural and anthropogenic catastrophes, the California Department of Fish and Game commissioned this study. Its objectives were to survey the lower segments of the Merced, San Joaquin, Stanislaus, and Tuolumne rivers for populations of Brush Rabbits and to assess the suitability of riparian communities along these streams to support Brush Rabbits. In areas outside of Caswell MSP where Brush Rabbits were found, population densities, extent of habitat, and potential threats to populations were to be determined.

## METHODS

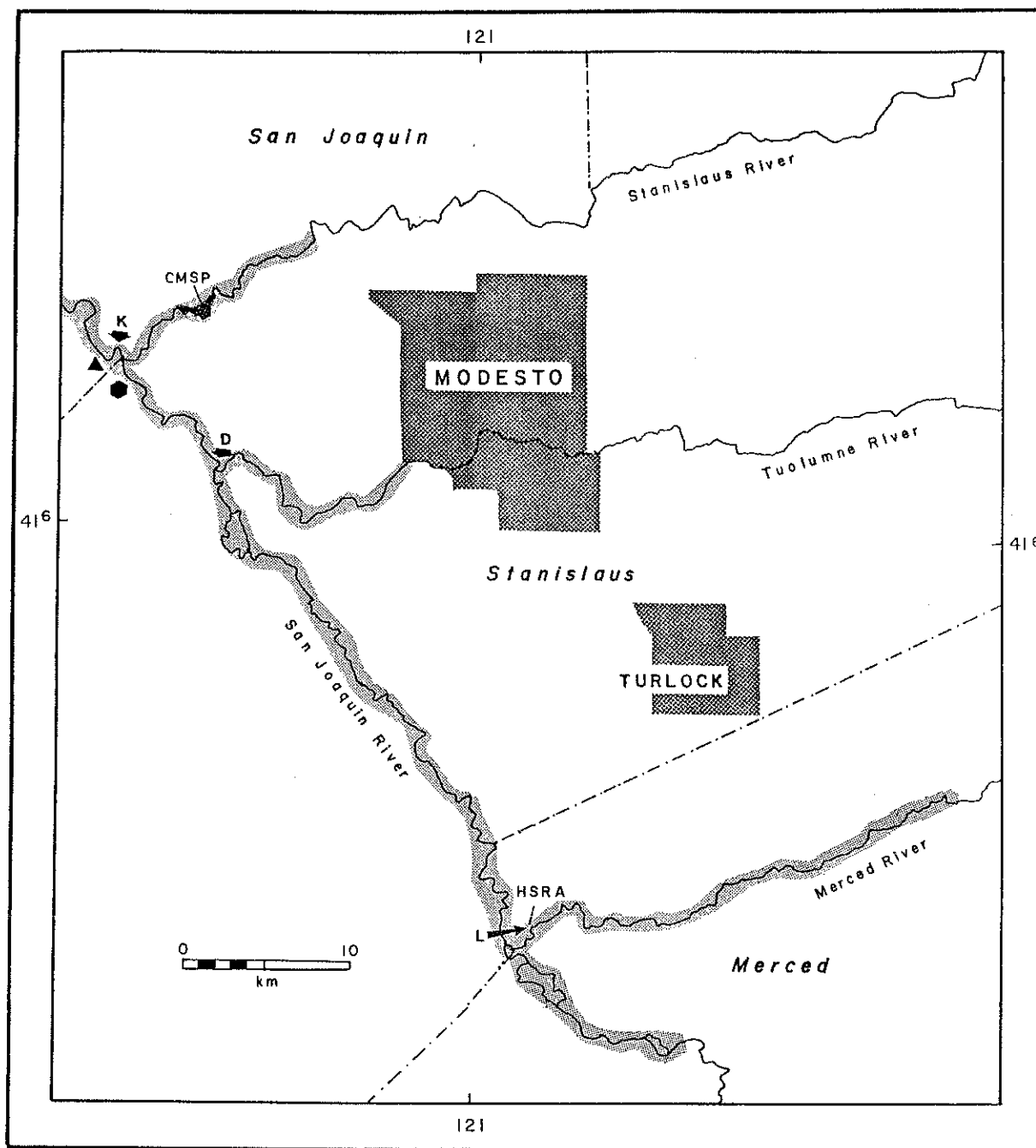
Field surveys were conducted between June and August 1986, and included the following areas within the flood dikes (Fig. 3): Merced River from Merced County Highway J-7 westward to its junction with the San Joaquin River, all in Merced County; San Joaquin River from California Highway 165 in Merced County westward and northward to its confluence with the Stanislaus River in San Joaquin and Stanislaus counties; Tuolumne River from the City of Modesto westward to its junction with the San Joaquin River, all in Stanislaus County; and the Stanislaus River from California Highway 99 in the City of Ripon westward to its junction with the San Joaquin River, the river forming the boundaries of San Joaquin and Stanislaus counties.

Most areas were surveyed from a small, shallow-draft boat so that both banks could be inspected simultaneously and to expedite access to private property fragmented among hundreds of owners. Aerial photos of the Stanislaus and San Joaquin rivers were used to locate potential sites with riparian communities around old oxbow lakes, away from present streams and outside of flood-control dikes. Areas located in this manner were also inspected.

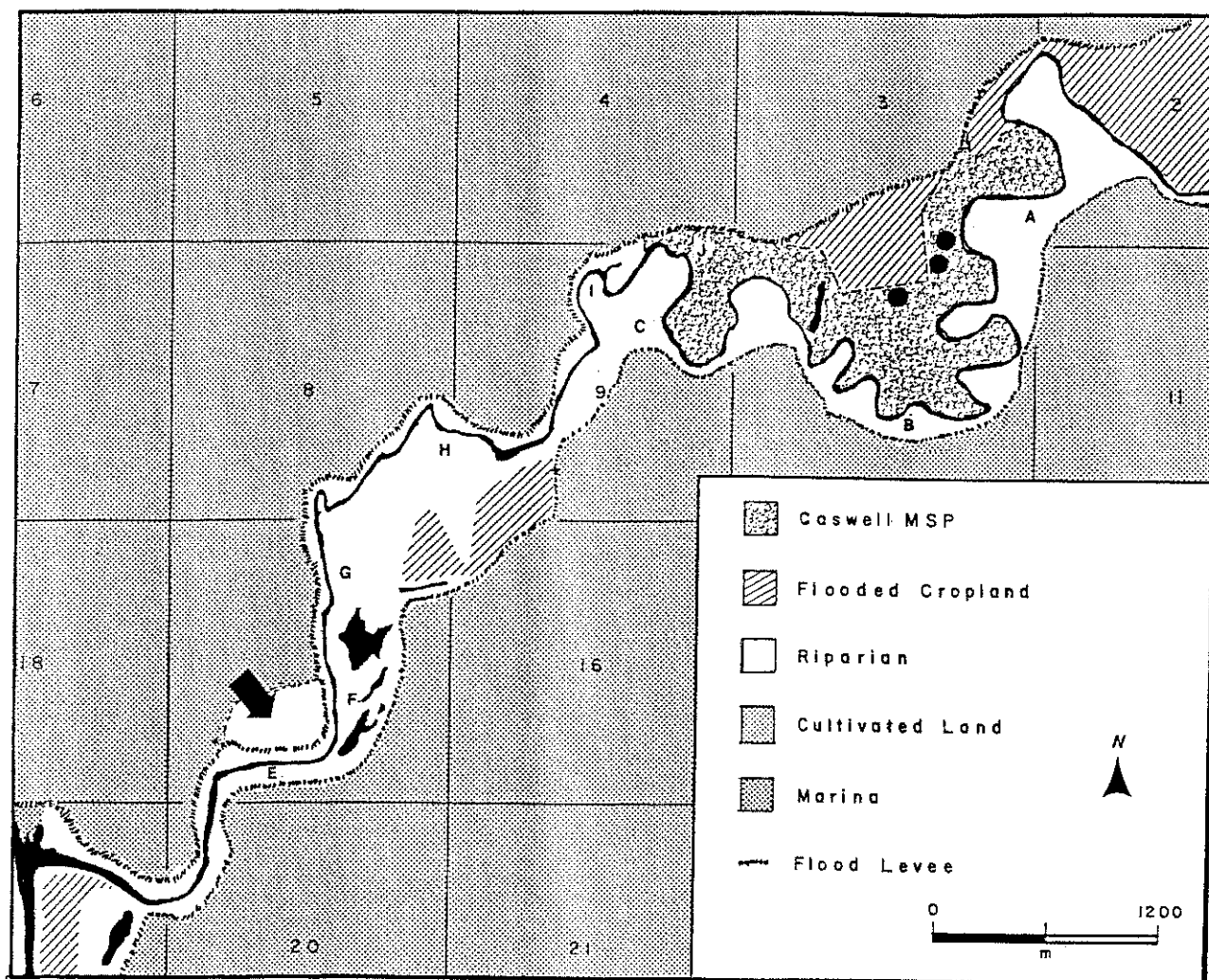
Along the course of each stream wherever potential habitat for Riparian Brush Rabbits was located it was inspected for runways, rabbit pellets, and other evidence of occupation. At 10 sites (A to J, Table 1 and Figs. 3 and 4) found to be occupied by cottontails (*Sylvilagus* spp.), Tomahawk, wire-mesh, double-door livetraps (mostly 63.5 by 15.2 by 15.2 cm, but some larger traps were also used) were placed in runways, baited with rolled oats, and operated for a continuous three-day period. Traps were checked twice daily in morning and evening. Two sites where no evidence of rabbits was found, but which appeared to offer some potential to support Brush Rabbits, were also trapped for three-day periods. These were located at Sturgeon Bend, on the San Joaquin River (site K, Table 1 and Fig. 3), and in George J. Hatfield State Recreation Area (SRA) on the Merced River (site L, Table 1 and Fig. 3).

At 30 sites (10 supporting populations of Brush Rabbits within Caswell MSP, 10 judged to provide good-to-moderate quality habitat, and 10 with what was considered to be poor quality habitat), 30-meter transects were established and measurements of ground, shrub, and canopy cover, and other aspects of the structure and environment of the plant community were recorded (listed below). Sites without Brush Rabbits, but judged to provide moderate-to-good quality habitat (hereafter referred to as potential habitat), all showed evidence of occupation by cottontails (*Sylvilagus* sp.), based either on sightings of Desert Cottontails or presence of runways and pellets. Numbers of runways and fecal pellets of cottontails found along the transect were also recorded.

Categories for characteristics of plant communities were patterned after floristic studies reported by Warner (1984). Prominent plants in the overstory (*i.e.*, greater than 2 m in height) included valley oak



**Figure 3.** Study area in central California. Historic records for *S. b. riparius* are same as in Fig. 2. Extent of riparian communities surveyed is indicated by the light shading along rivers. Trapping sites D, K, and L are referenced in Table 1. CMSP = Caswell Memorial State Park; HSRA = Hatfield State Recreation Area.



**Figure 4.** Lower Stanislaus River with trapping sites A - C and E - J (Table 1). Dots indicate where Riparian Brush Rabbits have been trapped. Rivers and oxbows are shown in black; the San Joaquin River is in the lower left corner. Riparian and flooded cropland are Federal and private lands with Army Corps of Engineers easements (see text). Location of a riparian area outside the levee is indicated by the arrow opposite site E. Section numbers are for T3S, R7E, Diablo Baseline Meridian.

(*Quercus lobata*), Fremont cottonwood (*Populus fremontii*), box elder (*Acer negundo*), and blue elderberry (*Sambucus caerulea*); others less commonly represented in the overstory were willows, black walnut (*Juglans hindsii*), black locust (*Robinia psuedoacacia*), and coyote bush (but the last treated as an understory shrub in statistical analyses). Although wild grape (*Vitis californica*) contributed significantly to

the canopy cover, for statistical analyses the host tree rather than grape was considered to provide the cover. Principal understory woody plants were California rose, Pacific blackberry, wild grape, coyote bush, and willows; others less commonly found were poison oak (*Rhus diversiloba*) and tree tobacco (*Nicotiana glauca*). Seedlings and saplings of several trees were also noted in the understory. Variables of plant community composition and structure, with separately recorded categories in parentheses, were as follows: canopy cover (oak, box elder, willow, cottonwood, locust, elderberry, all others, total); average height of herbaceous cover; length of ground cover (herbs, sedges, downed woody material, litter, bare soil, total of herbs plus sedges); length and height of understory cover (rose, blackberry, tree seedlings, grape, coyote bush, willows, all others); understory area (length x height of above categories); soil type; and height of 1986 flood line. Understory area measures a three-dimensional slice through the community.

Data from transects of plant communities were summarized statistically and compared for significant differences between sites occupied by Brush Rabbits and unoccupied sites, with separate comparisons made between sites occupied by *S. audubonii* and sites unoccupied by either species, and with a lumped sample of all sites not occupied by Brush Rabbits. Data were tested for significance by 2-tailed, paired *t*-tests. Pearson product correlation coefficients were calculated between habitat variables. Other multivariate analyses proved inconclusive and are not included in the results.

## RESULTS

Results of trapping for Riparian Brush Rabbits at 12 sites are summarized in Table 1. No Brush Rabbits were captured and no other evidence of Brush Rabbits was found outside of Caswell MSP. Few sites outside of the park were judged to have potential to support populations. Desert Cottontails, *S. audubonii*, were present at most sites where there was potential habitat for Brush Rabbits (Table 1).

A summary of statistical analyses of plant community variables are presented in Table 2. Some species groups of plants were represented on so few transects that those data are not included in Table 2. Height of understory cover is not included in Table 2, but the data are represented in combined form in calculations of understory area. Soils at all sites were of nearly the same texture, a mix of very fine sands and silts of alluvial origin. Because of lack of variation, data on soil texture were not analyzed statistically.

The height of the 1986 floodline was not evident at many sites, thus this variable was not included in statistical analyses. For one transect at a site occupied by Brush Rabbits, the height of the 1986 floodline was 0.8 m; other occupied sites also probably had flood levels during winter 1986 of less than 1 meter, as they were all located in the same general area of Caswell MSP. Transects at sites occupied by Desert Cottontails had 1986 floodlines from 1.0 to 1.7 m (mean 1.55,  $n = 4$ ), and sites not occupied by either species ranged from 1.5 to 3.0 m (mean 2.24,  $n = 5$ ).

Few significant differences were found between sites occupied by Riparian Brush Rabbits and unoccupied sites within the geographic range that were judged to provide potential habitat for Riparian Brush Rabbits. Most noteworthy was the scarcity of willows in the overstory of occupied sites and an absence of seedling and sapling willows in the understory. Also of significance were the greater areas (measured as length times height along transect) of roses in the understory of sites occupied by Brush Rabbits, and the lack of ground litter at sites occupied by Desert Cottontails.

No variables were significantly correlated with presence of Riparian Brush Rabbits, although inhabited sites typically had a mix of roses, blackberries, coyote bushes, and grapes, and few or no willows. More sites with relatively high quantities (as measured by area) of roses, coyote bushes, and grapes were inhabited than those with only high quantities of blackberries. There were a number of significant correlations among variables of plant community structure, mostly between related measures of understory length, height, and area for a given plant type. Correlations with relevance to this study include a significant negative correlation between canopy cover and area of understory ( $r = -0.508$ ,  $P < 0.01$ , d.f. = 28) over all sites, and a negative, but not significant, correlation between canopy cover and herbaceous ground cover ( $r = -0.302$ ,  $0.05 < P < 0.10$ ). Sites with relatively large numbers of willows had few or no roses, blackberries, grapes, or coyote bushes as indicated by negative correlations between willows and other understory shrubs.

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**Table 1.** Trapping program and captures of mammals at 12 sites potentially occupied by Riparian Brush Rabbits on the lower Merced, San Joaquin, Stanislaus, and Tuolumne rivers, central California, during summer, 1986. Geographic location of sites designated by letters are depicted in Figs. 3 and 4.

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Site	Dates	Traps	Captures	
			Species	Numbers
A	2 - 4 Aug.	5	<i>Didelphis virginiana</i>	2
			<i>Neotoma fuscipes</i>	2
B	2 - 4 Aug.	5	<i>Mephitis mephitis</i>	1
			<i>Spermophilus beecheyi</i>	1
C	2 - 4 Aug.	5	<i>Sylvilagus audubonii</i>	2
			<i>Neotoma fuscipes</i>	2
D	2 - 4 Aug.	5	<i>Rattus rattus</i>	2
E	19 - 21 Aug.	6	<i>Rattus rattus</i>	3
F	19 - 21 Aug.	5	<i>Rattus rattus</i>	2
G	19 - 21 Aug.	5	<i>Didelphis virginiana</i>	2
			<i>Sylvilagus audubonii</i>	1
H	19 - 21 Aug.	5	<i>Sylvilagus audubonii</i>	2
			<i>Rattus rattus</i>	1
I	19 - 21 Aug.	5	<i>Sylvilagus audubonii</i>	1
			<i>Neotoma fuscipes</i>	4
J*	19 - 21 Aug.	5	<i>Sylvilagus audubonii</i>	1
			<i>Neotoma fuscipes</i>	1
K	19 - 21 Aug.	5		
L	18 - 20 Sept.	16	<i>Rattus rattus</i>	2

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\* This site was located within the boundary of Caswell Memorial State Park (see Fig. 4), all other trapping sites were located outside the park.

**Table 2.** Means, standard errors of means, and ranges for plant community variables at 30 sites: 10 occupied by *Sylvilagus bachmani*, 10 occupied by *S. audubonii*, and 10 unoccupied by either species. Canopy cover is by percentage; understory area is in square meters; all other values are linear measures (meters) along a 30-m transect; ground cover and shrub and understory cover were measured separately. Significant differences ( $P \leq 0.05$ , t-test) in values for sites occupied by Riparian Brush Rabbits and others are marked with an asterisk (\*).

Habitat variable	Brush Rabbit ( <i>S. bachmani</i> )		Desert Cottontail ( <i>S. audubonii</i> )		Unoccupied Sites	
	Mean±S.E.	Range	Mean±S.E.	Range	Mean±S.E.	Range
Canopy cover	65.1±8.2	23-94	56.5±11.5	0-100	79.1±6.8	26-100
oak	21.4±8.3	0-71	20.2±11.2	0-88	18.1±9.5	0-80
box elder	22.3±8.9	0-84	16.1±9.8	0-81	17.5±8.1	0-65
willow	2.0±1.3*	0-10	16.9±6.6*	0-58	23.0±9.2*	0-87
cottonwood	9.7±7.2	0-71	1.0±1.0	0-10	22.1±9.9	0-77
Herb height	0.7±0.06	0.4-1.0	0.6±0.05	0.4-0.8	0.7±0.2	0-2.0
Ground cover						
herbaceous	17.3±2.3	1-26	15.9±3.7	1.2-29.4	13.1±4.1	0-30.0
downed wood	0.1±0.1	0-1.0	0.9±0.4	0-4.2	0.5±0.3	0-2.8
litter	5.7±2.6*	0-26.7	0±0*	0-0	3.6±2.4	0-18.4
Bare soil	7.2±1.9	0-16.2	13.2±3.7	0-28.7	12.8±3.9	0-29.5
Understory cover	20.9±3.2	0-30.0	20.5±2.6	1.0-28.2	15.5±3.1	0-30.0
rose	5.3±2.2	0-16.0	4.5±1.8	0-13.1	0.7±0.4	0-4.1
blackberry	7.2±2.3	0-21.5	7.0±0.2	0-19.7	8.4±3.0	0-29.3
tree seedlings	0.3±0.1	0-1.4	0.5±0.3	0-3.0	0.3±0.2	0-2.0
grape	5.3±2.7	0-23.6	1.2±0.7	0-6.1	2.6±1.6	0-14.1
coyote bush	2.9±1.4	0-14.4	3.1±2.1	0-19.7	0.3±0.2	0-2.0
willow	0±0*	0-0	4.3±2.9*	0-27.1	2.6±1.4*	0-14.7
Understory area	313.8±65.4	0-590.2	443.6±126.4	4.0-1355.0	281.2±80.4	0-837.5
rose	82.8±36.9*	0-320.0	72.4±29.6	0-239.7	14.1±9.5*	0-92.3
blackberry	100.4±35.6	0-333.3	66.6±19.7	0-153.0	77.6±24.8	0-213.4
tree seedlings	7.8±4.5	0-39.2	8.9±5.1	0-48.0	6.9±5.9	0-60.0
grape	55.4±25.6	0-228.8	21.6±14.8	0-136.5	47.3±29.5	0-282.6
coyote bush	67.3±39.5	0-394.6	101.7±67.5	0-531.9	3.6±2.6	0-24.0
willow	0±0*	0-0	172.8±136.0*	0-1360.0	109.0±67.1*	0-675.0

## DISCUSSION

Presence of seedling and sapling willows in the understory, a predominance of willows in the overstory, and little or no ground litter are characteristic of lower-lying, frequently flooded ground that is undergoing succession. No such areas were found to be inhabited by Riparian Brush Rabbits, but this may be because there were no places nearby to escape from floods. Sites preferred by Riparian Brush Rabbits had an open canopy, primarily of oaks and box elders and secondarily of cottonwoods, and an understory of a nearly equal mix of roses, blackberries and grapes; herbaceous plants were found along slightly more than one-half of the length of transects (Table 2).

Overall, no sites outside of Caswell MSP provide significant potential to support Riparian Brush Rabbits under present conditions because of lack of protection from floods or relatively small size of extant uncultivated areas. Remaining refuges from winter floods are on the narrow dikes and in agricultural fields adjacent to dikes. In many places the lower ends of agricultural fields outside of levees also hold standing water during winter flooding. Typically, neither levees nor adjacent fields provide cover for Riparian Brush Rabbits. Even at Caswell MSP, the entire park is subject to inundation, and the levee to the north of the MSP boundary presently is kept nearly free of plants by use of herbicides.

On the Merced River, agricultural fields generally extend to near the banks of the river and the remnant riparian vegetation found along the banks is subjected to frequent flooding. No relatively large, uncultivated floodplain areas remain and most extant areas are partly cleared of trees and shrubs and used as pasture, developed parks, or as home sites. Only the undeveloped portion of Hatfield SRA includes a few hectares (less than 10 acres) of potential habitat for Riparian Brush Rabbits. However, no evidence of *Sylvilagus* spp. was found there during this study (site L, Table 1, Fig. 3).

On the Tuolumne River, potential habitat for Riparian Brush Rabbits was found only within uncultivated areas near the mouth of the river. Most of this area is cleared and used as pasture, and no fully developed riparian plant community exists. No evidence of Riparian Brush Rabbits was found at the single site that was trapped (site D, Table 1, Fig. 3).

There are greater expanses of uncultivated land within the floodplain of the San Joaquin River, from near the mouth of the Tuolumne River to the mouth of the Stanislaus River, than along any of the other rivers examined. However, all of the remnant riparian stands are subjected to periodic, prolonged flooding. A single site opposite the mouth of the Stanislaus River (site K, Table 1, Fig. 2) was trapped during this study. The entire course of the lower San Joaquin River, from Friant Dam, Madera County, to near Stockton, San Joaquin County was examined and several sites were trapped to determine presence of Riparian Brush Rabbits in 1985 (G. Basey, ESA, unpubl. data). The segment in Merced and Stanislaus counties was reexamined during this study and was also examined and trapped during spring 1986 to determine presence of

Riparian Woodrats (*Neotoma fuscipes riparia*; G. Miller, ESA, unpubl. data). No evidence of Riparian Brush Rabbits was found during these inventories.

For sites along the Stanislaus River the general lack of significant differences between plant community variables of sites occupied by Desert Cottontails and those occupied by Riparian Brush Rabbits (Fig. 4) suggests that the former sites offer some potential as habitat for Riparian Brush Rabbits. The presence of willows in the understory, a prominent willow component in the overstory, and absence of ground litter, however, show that these sites are subjected to greater frequency and duration of flooding than those occupied by Riparian Brush Rabbits (Table 2). Other differences between sites presently inhabited by Riparian Brush Rabbits and unoccupied sites are sizes of habitat area and winter flood levels. Unoccupied sites judged to be potential habitat for Riparian Brush Rabbits were located in areas subjected to higher flood levels and probably floods of longer duration, and had considerably smaller amounts of shrubby vegetation.

During the past 20 years there have been rapid changes in cultivation practices along the historic floodplains of the main tributaries of the lower San Joaquin River system. Changes probably are due mainly to the completion of dams on these tributaries that have individually and collectively reduced the frequency and severity of flooding: New Exchequer Dam on the Merced River; New Melones Dam on the Stanislaus River; and New Don Pedro Dam on the Tuolumne River. The earlier construction of flood control levees was also important in the changes in land use.

Prior to construction of dams and levees, much land that was periodically flooded was used as pasture; it was uneven in topography with some ground remaining above typical flood levels, and contained numerous patches of shrubs and trees. Such sites probably provided refuge to Riparian Brush Rabbits during flooding. Virtually all areas outside of flood-control levees now have been cleared, leveled, and planted as orchards, vineyards, or annual row crops. Conversion from pasture to cultivated fields was accompanied by removal of most fences and the cover of blackberries and weeds along fence lines, areas that probably offered avenues of retreat and refuge from floods.

Protection from flooding has also resulted in an explosive growth of homes and other structures in the historic floodplains of these streams, increasing the densities of humans, livestock, and domestic cats and dogs.

The collective impacts of these developments, the loss of habitat and refuges from floods for Riparian Brush Rabbits and a probable increase in predation on their populations, has resulted in their extirpation everywhere except Caswell MSP.

Flood-control levees now provide virtually the only potential sites above flood levels for Riparian Brush Rabbits and other terrestrial species requiring riparian habitat. However, they afford little or no cover to hide from predators or to shelter from adverse weather. Although control of vegetation on levees is important in levee

maintenance, both by reducing breaks during flooding and facilitating inspection of levees (Nolan 1984), this practice probably has contributed significantly to the extirpation of populations of Riparian Brush Rabbits in areas subjected to frequent and prolonged flooding.

Riparian Brush Rabbits have been found in trees during flooding in Caswell MSP (K. Martin, pers. comm.). Rabbits probably climb into tangles of brush during mild flooding, and may swim to and climb into trees when flood waters deepen. Presence of large, leaning trees and box elders, elderberries, and other small, bushy trees may provide emergency shelter and food during floods. How long Riparian Brush Rabbits can survive in this manner and how adept they are at climbing trees are unknown.

In Caswell MSP, treed rabbits were rescued by boat and released on dry ground by Park Manager Ken Martin during flooding in the spring of 1976. It is possible that this rescue saved the only remaining Riparian Brush Rabbit population from extinction.

Chapman (1974) remarked that Brush Rabbits in Oregon, kept in 9.1 by 18.3 m enclosures, hid and rested in small fir trees, 1.2 to 1.5 m above ground. Ingles (1941) and Summer (1931) recorded observations of *S. audubonii* climbing brush piles and trees. Verts *et al.* (1984) observed tree climbing behavior in *S. nuttallii*. Thus, at least two other members of the genus have limited abilities to climb trees.

Competition with the Desert Cottontail may be an important factor in the extirpation of populations of Riparian Brush Rabbits. *S. audubonii* has greater vagility and uses a broader range of plant communities than *S. bachmani* (Chapman *et al.* 1982). In central California, *S. audubonii* is usually associated with riparian communities with thickets of willows, blackberries, and other shrubs (Chapman and Willner 1978, Orr 1940), but is also found in open grasslands far from trees and shrubs. Desert Cottontails typically need some type of cover -- shrubs, dense grass, rocks, or human-made structures -- but may range far from cover to feed.

Desert Cottontails have fewer than three young per litter, on average, but mature sexually in as little as 80 days, and often breed year round in central California (Chapman and Willner 1978), whereas the Brush Rabbit does not mature until the next annual breeding season and has a limited period for reproduction. The relatively low fecundity of *S. bachmani*, its dependence on nearly continuous shrub cover, and its poor vagility probably make it competitively inferior to *S. audubonii* in ecotone communities between the riparian shrublands and the open, xeric plant communities of the San Joaquin Valley.

Also because of their low vagility and fecundity, populations of Riparian Brush Rabbit are more likely to be extirpated by flooding than are Desert Cottontails. In the reduced, fragmented, and altered riparian communities within the geographic range of the Riparian Brush Rabbit ecotone habitat predominates. Under these conditions, Riparian Brush Rabbits probably have little chance to naturally recolonize suitable sites where they have been extirpated.

If protected from flooding, habitat for Riparian Brush Rabbits could become available across the Stanislaus River (south or Stanislaus County side) from Caswell MSP and downstream to the mouth on both sides of the river, and in the floodplain of the San Joaquin River, primarily between the mouths of the Tuolumne and Stanislaus Rivers (Figs. 4 and 5).

On the Stanislaus River, the potential habitat is designated as Wildlife Habitat by the Army Corps of Engineers (COE), in mitigation for loss of habitat from construction and operation of the New Melones Dam (Kindel, 1984). All of this property is within the river levees and the 8,000 CFS flood lines (Fig. 4). A small amount is federally-owned land, administered by the COE; most, however, is private land on which federal easements have been established. Easement categories are Fish and Wildlife Habitat Protection, Ordinary Flowage, and Channel Maintenance. Most parcels have multiple-category easements: Fish and Wildlife Habitat Protection and Ordinary Flowage or Channel Maintenance (COE, in litt.).

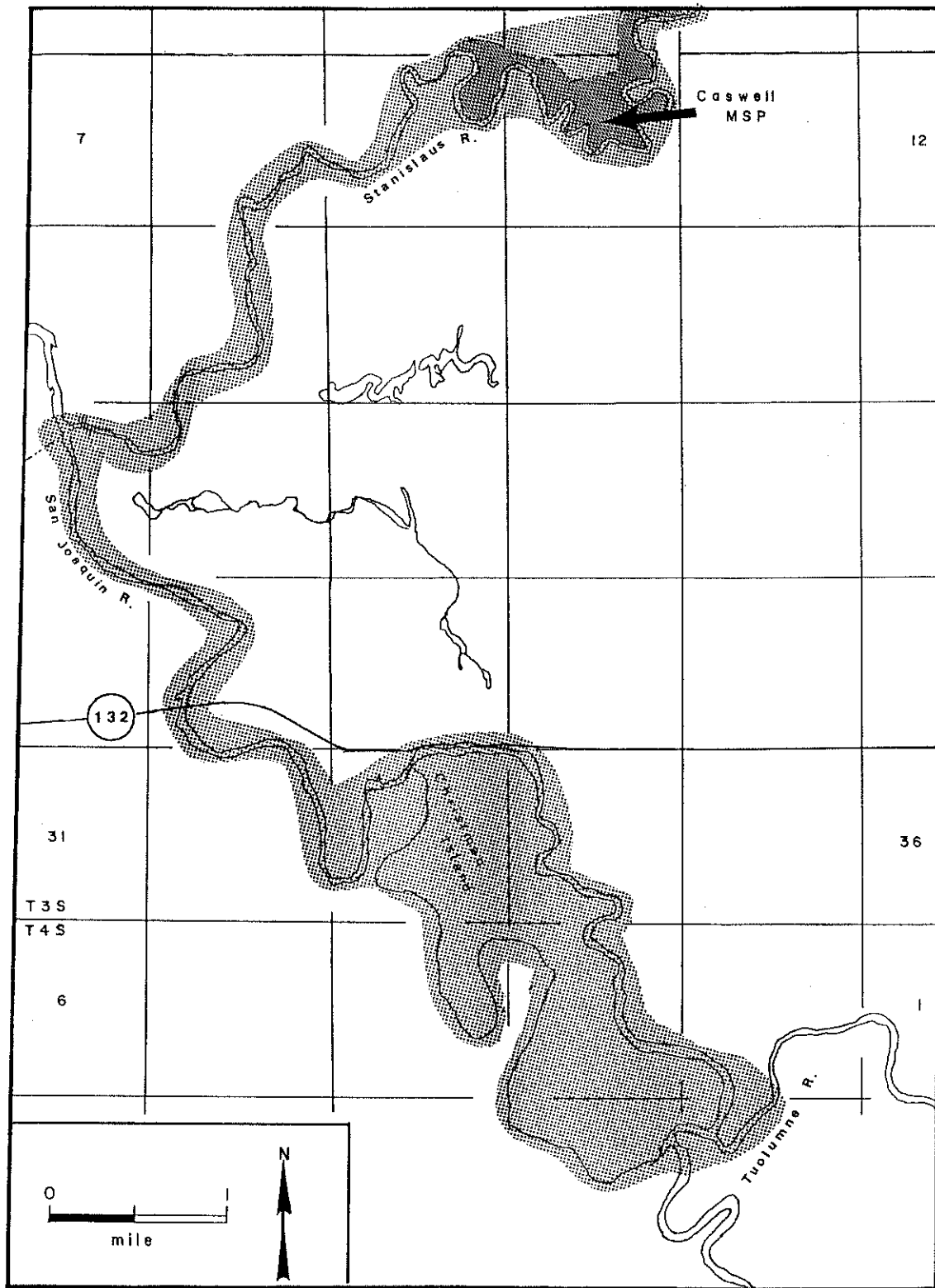
Owners of property with Fish and Wildlife Habitat Protection easements may graze livestock and use it for other purposes, but may not destroy wildlife habitat. Management by the COE consists only of periodic monitoring, mostly by overflight, to check for removal of wildlife habitat. There apparently has been no attempt to enhance habitat or to control the level of grazing, and no indication that consideration has been given to requirements of terrestrial species such as Riparian Brush Rabbits living in the easement areas and vulnerable to flooding.

Population densities of Riparian Brush Rabbits on a study grid in Caswell MSP decreased from a pre-flooding estimate of 82 rabbits per ha in 1985 to less than 10 rabbits per ha during August and September 1986. Since August, 1986, three trapping sessions of 3, 3, and 6 days resulted in the capture of two Riparian Brush Rabbits on the grid. The grid represented one of a few sites with relatively high densities of Riparian Brush Rabbits, but several Riparian Brush Rabbits were seen and trapped elsewhere in the park. During this study, a Desert Cottontail was trapped for the first time within Caswell MSP, near the western or downstream boundary (Site J, Table 1 and Fig. 4; Williams and Basey 1986).

Although population fluctuations are normal for *Sylvilagus* spp., there is little evidence suggesting pronounced cyclic periodicity in density (Chapman *et al.* 1982). No data on extent or causes of fluctuations are available for *S. bachmani* (Chapman 1974, Chapman *et al.* 1982). The magnitude of change in pre- and post-flooding densities on the grid is probably within the normal level of population fluctuations, but the present situation emphasizes the precarious position of the only population of Riparian Brush Rabbits.

Fire, flooding, or a combination of these or other factors such as predation, epidemic disease, and increased competition with Desert Cottontails could cause the almost instantaneous extinction of the Riparian Brush Rabbit.

Prompt action must be taken to ensure the survival of *S. b. riparius*. Highest priority should be given to providing safe refuges from



**Figure 5.** Approximate area in central California with potential habitat for Riparian Brush Rabbits (shaded area). Protection from flooding of high ground, transplantation of *S. b. riparius*, and prohibition of hunting of rabbits between flood levees within the area shown are recommended.

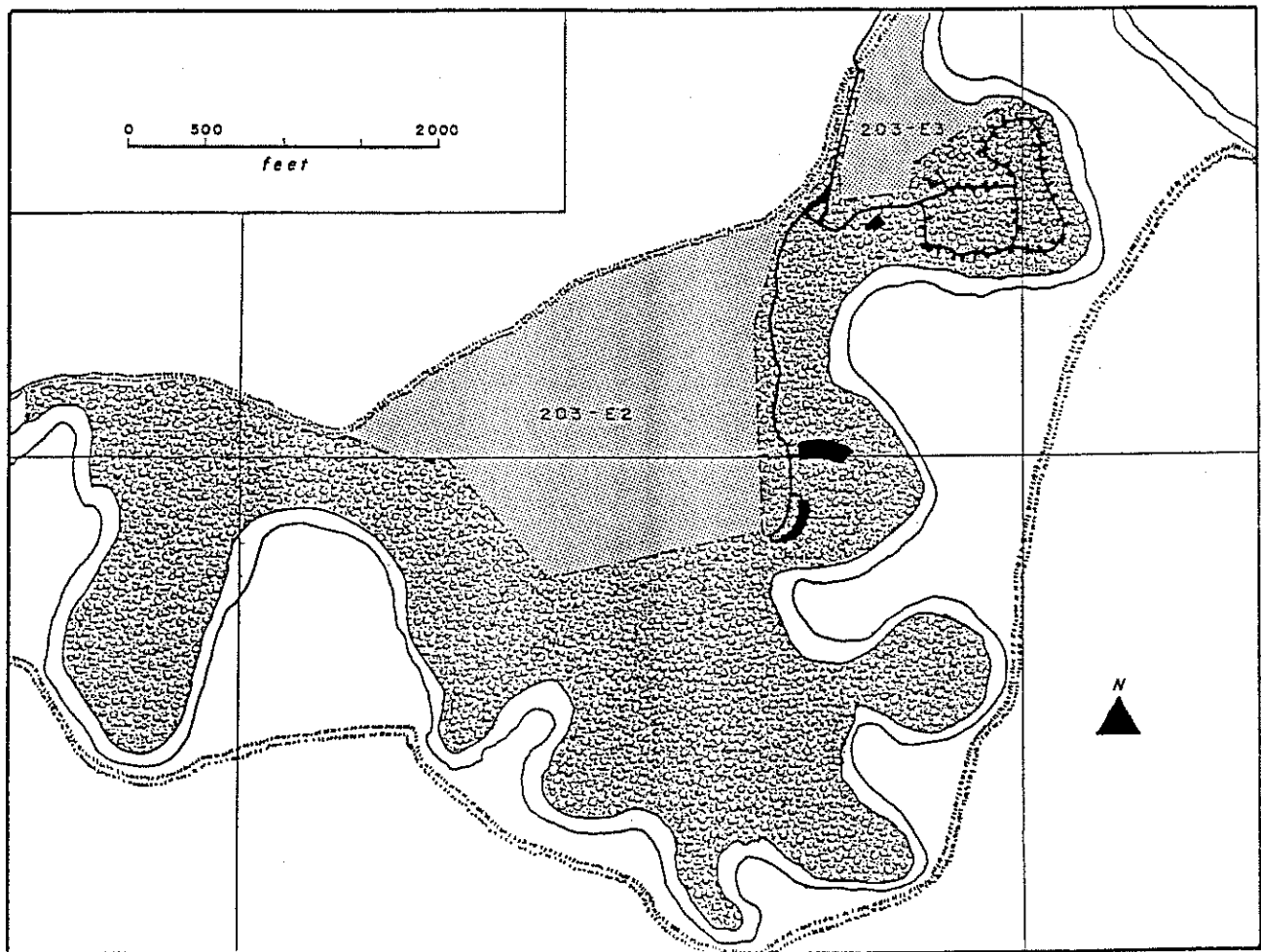
flooding for the remaining population in Caswell MSP. Immediate modification of vegetation-control practices on the existing levee bordering Caswell MSP is needed (Fig. 6). Instead of using broad spectrum herbicides during winter, the area should be seeded to sod-forming grasses and maintained so that they stand at least 25 cm high by the start of the winter flood season. These recommendations are within levee maintenance standards and procedures of the COE (Nolan 1984).

Other, more substantial actions also are needed to ensure safety from flooding, and might be accomplished in one or a combination of ways: build up areas of higher ground within the park and place piles of tree prunings on these areas for temporary cover, until shrubs become established; construct a levee along the north edge of the park bordering on the cultivated field (parcel 203-E2 of Brocchini Ordinary Flowage Easement, COE; Fig. 6); and widen the existing levee, creating berms on which shrubs can be planted and maintained without risk of weakening the levee.

The major areas within Caswell MSP occupied by Riparian Brush Rabbit are located on the highest ground bordering the Brocchini property (parcel 203-E2; Fig. 6), which is maintained in cultivated annual crops. Creation of a new levee along the park boundary would provide a readily accessible refuge for rabbits, but either would require destruction of existing habitat or use of privately owned property. Expansion of the existing levee would also require reduction in cultivated area. The distances across cultivated ground from areas inhabited by Riparian Brush Rabbits to the levee range up to 460 m (1500 ft); most occupied areas are more than 300 m from the levee, although the levee borders the park along its western boundary (Fig. 6). Thus, the levee is probably too inaccessible for many rabbits under present conditions.

Building up areas within the park would require alteration and at least temporary loss of habitat. Sources of soil to accomplish this task are also uncertain. One potential solution is to obtain soils from the Brocchini property to widen the levee and create mounds of higher ground between the levee and the existing park. Imported soils also could be added to the higher ground along the boundary between this parcel and the park. The entire built-up area could then be planted with native trees and understory shrubs and managed for Riparian Brush Rabbits.

High management priority must also be given to reestablishing one or more populations of Riparian Brush Rabbits where they have been extirpated to significantly lessen chances of extinction by a single catastrophe. Moderate-sized blocks of potential habitat, already in COE Fish and Wildlife Habitat Protection Easements, are found downstream from Caswell MSP (Fig. 4). To be suitable habitat, these areas must be modified to lessen the extent and frequency of flooding. One small area of uncultivated ground is located outside the north levee near the mouth of the river (opposite site E, Fig. 4). Acquisition and restoration of vegetation on this site could provide a small, but significant new refuge for Riparian Brush Rabbits that would be protected from normal flooding.



**Figure 6.** Caswell Memorial State Park (tree-shading) and vicinity. Flood levees are double, broken lines. Numbers reference Brocchini property suggested for acquisition and modification to provide refuge sites and habitat for Riparian Brush Rabbits.

A few sites along the San Joaquin River have potential for maintaining a reintroduced population of Riparian Brush Rabbits, but require creation of substantial elevated areas as refuge from floods and changes in current land use patterns to encourage establishment of more shrubs and trees. The Christman Island property, a 316 ha (780 acre) parcel in the floodplain of the San Joaquin River in Stanislaus County, was recently acquired by the National Audubon Society for addition to the California Wetlands and Waterfowl Program and the National Wildlife

Refuge System (U.S. Fish and Wildlife Service, in litt.; Fig. 6). Parts of this parcel have considerable potential to support a reintroduced population of Riparian Brush Rabbits.

Undeveloped lands along the Tuolumne River offer little potential to support a population of Riparian Brush Rabbits. On the Merced River, a small population of Riparian Brush Rabbits possibly could be established in the undeveloped portion of Hatfield SRA without the need for much alteration to the plant community. The area is small (less than 3 ha) and not protected from flooding, however. The flood levee is separated from park property by cultivated fields.

Other public properties include Fremont Ford State Recreation Area on the San Joaquin River. This property is often severely flooded and in its present condition offers little or no potential for supporting a population of Riparian Brush Rabbits. Further evaluation of properties administered by the California Department of Parks and Recreation is in progress and will be the subject of a future report.

Because Riparian Brush Rabbits and Desert Cottontails from riparian communities in central California are superficially similar in size, coloration, and appearance, hunters would be unable to distinguish the two species. Furthermore, many hunters probably would fail to distinguish young Black-tailed Hares (*Lepus californicus*) from Riparian Brush Rabbits.

Prohibition of hunting of all species of rabbits and hares in and around reintroduction sites will be necessary to insure the successful establishment and maintenance of new Riparian Brush Rabbit populations. Closure by the California Fish and Game Commission of these areas to hunting of rabbits and hares is recommended as a high-priority regulatory action.

The Riparian Brush Rabbit exists at a single site with a relatively low population number. It is highly vulnerable to extinction at that site from flooding, wildfire, and possibly disease and predation. State and federal Endangered status for the Riparian Brush Rabbit should be proposed to the California Fish and Game Commission and the Secretary of the U.S. Department of Interior.

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## LITERATURE CITED

- Chapman, J. A. 1971. Orientation and homing of the brush rabbit (*Sylvilagus bachmani*). J. Mamm. 52:686-699.
- \_\_\_\_\_. 1974. *Sylvilagus bachmani*. Mamm. Species 34:1-4.
- Chapman, J. A., and A. L. Harman. 1972. The breeding biology of a brush rabbit population. J. Wildl. Manage. 36:816-823.
- Chapman, J. A., and G. R. Willner. 1978. *Sylvilagus audubonii*. Mamm. Species 106:1-4.
- Chapman, J. A., J. G. Hockman, and W. R. Edwards. 1982. Cottontails. Pp. 83-123, in Wild mammals of North America (J. A. Chapman and G. A. Feldhamer, eds.). The Johns Hopkins Univ. Press, Baltimore, 1147 pp.
- Hall, E. R. 1981. The mammals of North America, 2nd. ed. John Wiley & Sons, New York, 1:1-600 + 90.
- Ingles, L. G. 1941. Natural history observations on the Audubon cottontail. J. Mamm. 22:227-250.
- Katibah, E. F. 1984. A brief history of riparian forests in the Central Valley of California Pp. 23-29, in California riparian systems ecology, conservation, and productive management (R. E. Warner and K. M. Hendrix, eds.). Univ. California Press, Berkeley, 1053 pp.
- Kindel, F. 1984. Riparian protection from Corps of Engineers projects. Pp. 895-898, in California riparian systems ecology, conservation, and productive management (R. E. Warner and K. M. Hendrix, eds.). Univ. California Press, Berkeley, 1053 pp.
- Mossman, A. S. 1955. Reproduction of the brush rabbit in California. J. Wildl. Manage. 19:177-184.

- Nolan, M. F. 1984. Vegetation on US Army Corps of Engineers project levees in the Sacramento/San Joaquin Valley, California. Pp. 538-547, in California riparian systems ecology, conservation, and productive management (R. E. Warner and K. M. Hendrix, eds.). Univ. California Press, Berkeley, 1053 pp.
- Orr, R. T. 1935. Description of three new races of brush rabbit from California. Proc. Biol. Soc. Washington 48:27-30.
- \_\_\_\_\_. 1940. The rabbits of California. Occas. Papers California Acad. Sci. 19:1-227.
- Summer, E. L. 1931. Some notes on the birds and animals of Los Banos duck refuge with special reference to predatory species. California Fish and Game 17:270-280.
- Verts, B. J., S. D. Gehman, and K. J. Hundertmark. 1984. *Sylvilagus nuttallii*: a semiarboreal lagomorph. J. Mamm. 65:131-135.
- Warner, R. E. 1984. Structural, floristic, and condition inventory of Central Valley riparian systems. Pp. 356-374, in California riparian systems ecology, conservation, and productive management (R. E. Warner and K. M. Hendrix, eds.). Univ. California Press, Berkeley, 1053 pp.
- Williams, D. F. 1986. Mammalian species of special concern in California. California Dep. Fish and Game, Wildl. Manage. Div. Admin. Report 86:1-112.
- Williams, D. F., and G. E. Basey. 1986. Ecology and habitat management of the Riparian Brush Rabbit in Caswell Memorial State Recreation Area. California Dep. of Parks and Recreation, Inland Region, Prog. Report, Interagency Agreement 4-304-6108, 6 pp.
- Williams, D. F., and K. S. Kilburn. 1984. Sensitive, threatened, and endangered mammals of riparian and other wetland communities in California. Pp. 950-956, in California riparian systems ecology, conservation, and productive management (R. E. Warner and K. M. Hendrix, eds.). Univ. California Press, Berkeley, 1053 pp.