THE STATUS AND KNOWN DISTRIBUTION OF THE SAN BERNARDINO KANGAROO RAT (*Dipodmys merriami parvus*):field surveys conducted between 1987 and 1996

Prepared for:
U.S. Fish and Wildlife Service
Carlsbad Field Office
2730 Loker Avenue West
Carlsbad, California 92008

Prepared by:
Robert L. McKernan
Curator of Biological Science
San Bernardino County Museum
2024 Orange Tree Lane
Redlands, California 92374

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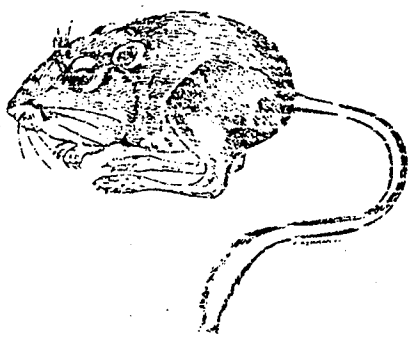

TABLE OF CONTENTS

FIGURES

TABLES

INTRODUCTION.

Within California there are three recognized subspecies of Merriam's kangaroo rat; Dipodomys merriami merriami, D. merriami collinus, and D. merriami parvus. The San Bernardino kangaroo rat D. merriami parvus is considerably darker and smaller than the other two subspecies (Lidicker, 1960). The cismontane occurring San Bernardino kangaroo rat (SBKR) appears similar to D. merriami merriami, but size and weight averaging smaller (approximately 14% n=143)(Table 1). The pelage is faintly ochraceous (yellow) with a over-washed of dusky brown. Dipodomys merriami parvus differs sharply in color from its neighboring subspecies, which are principally flaxen (pale yellow) in color. The decided difference in external characters of D. merriami parvus and its nearly complete isolation from other members of D. merriami has elicited some biologist to note the possibility that D. merriami parvus has attained proximate species rank (Lidicker, 1960).

The San Bernardino kangaroo rat occurs primarily in alluvial fan sage scrub (AFSS) which is a distinct habitat type of the coastal sage scrub community (CSS). This subspecies has also been found to occur in Encelia dominated CSS where soils are suitable (i.e. sandy) (Art Davenport, USFWS, personal communication). Within the AFSS the early successional phases are preferred by SBKR. These early successional phases are defined as pioneer and intermediate. The AFSS habitats are confined to river and creek floodplains of southern San Bernardino and northwestern Riverside Counties. Within the historic range of the alluvial scrub habitats in these two counties the SBKR

Table 1. Average measurements of Dipodomys merriami subspecies

Subspecies	Total length	Tail length	Hind foot	Weight	Sample size
D. merriami parvus	*230mm*	*132mm*	*36.0mm*	*36.2g*	*143*
D. merriami collinus	*240mm*	*145mm*	*37.5mm*	*38.0g*	*24*
D. merriami merriami	*247mm*	*144mm*	*38.5mm*	*40.3g*	*178*

formerly occurred in at least 25 locations all of which were associated with fluvial environments (Figure 1 and 2). Although there has been major reduction in alluvial scrub habitats (Westman 1981), occupied SBKR habitat still exist from the southern portion of Cajon Pass, San Bernardino County south through the central and eastern portions of San Bernardino Valley extending to the subspecies known southern limit near Murrietta Hot Springs, Riverside County.

The quality and quantity of preferred habitat has declined over the last fifty years in the SBKR's range. These declines can be explained by changes in wash channelization and their associated infrastructures which now manage most of the fluvial systems in the coastal valleys of southern California. The fundamental feature of alluvial systems that provides the basis for suitable habitat for SBKR is the sandy substrate. With the reduction in alluvial systems so comes the reduction in suitable habitat for SBKR. As the reduction in size and the increase in management of floodplains continue, the fundamental habitat requirements for SBKR continue to diminish. These noted reductions in alluvial systems within cismontane southern California have also had negative consequence on a other native organism which exist in these habitats.

To understand the status, distribution, and habitat affinities of the SBKR, the Biological Science Section of the San Bernardino County Museum has been conducting a range wide assessment of the SBKR. This report outlines the current status of the SBKR, the estimated historic range, the current range, and those areas where through flood control and land conversion have

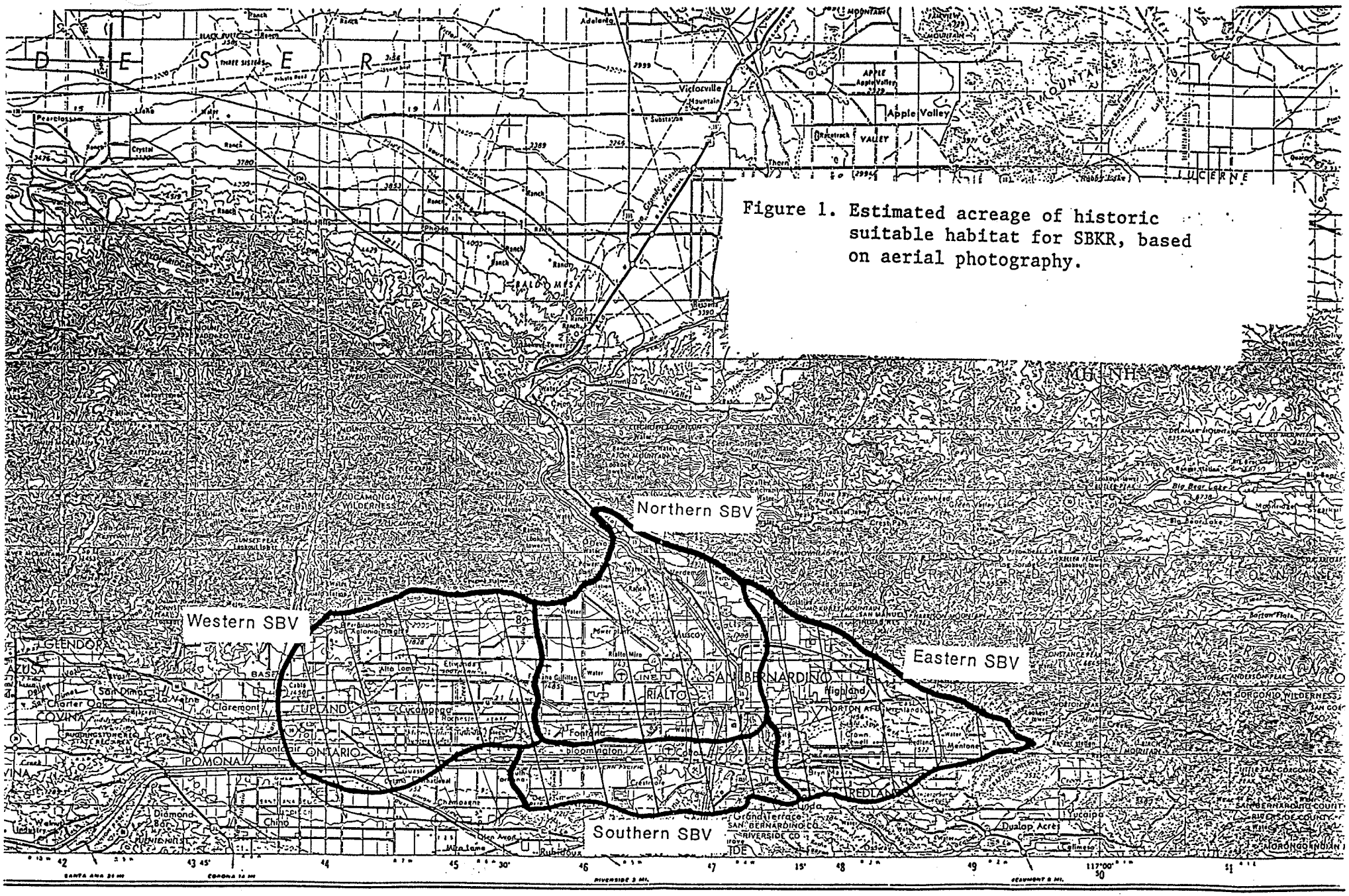

Figure 1. Estimated acreage of historic suitable habitat for SBKR, based on aerial photography.

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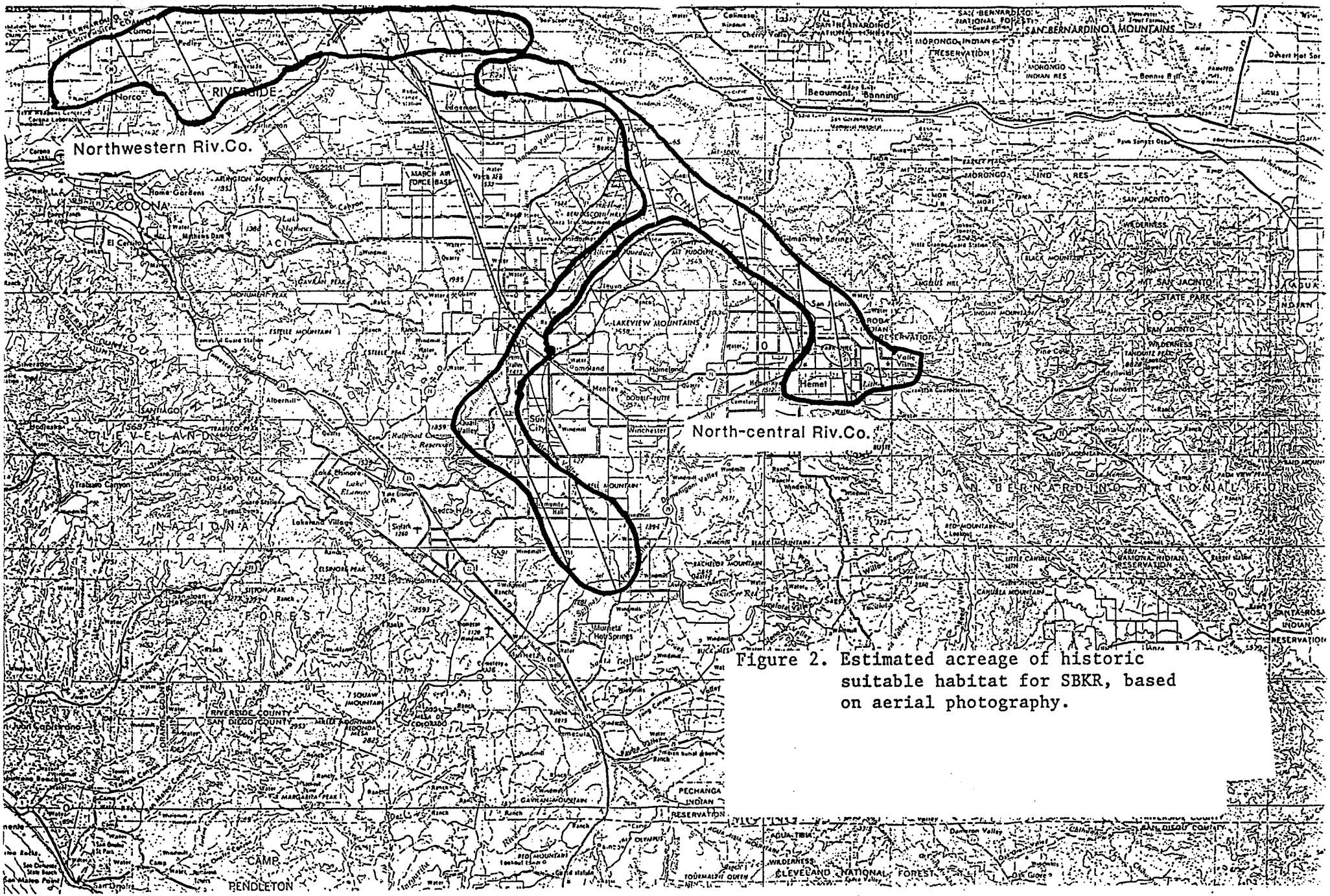


Figure 2. Estimated acreage of historic suitable habitat for SBKR, based on aerial photography.

eliminated the subspecies. In addition, information is provided regarding portions of the ecology of this species and is based on extant populations.

MATERIALS AND METHODS.

Museum records, literature, and aerial photographs were utilized to determine the estimated historic distribution of SBKR. The aerial photography spanned various years between 1933 through 1993. The principal locations where historic aerial photo's were taken are locations such as Santa Ana Wash, Cajon and Lytle Creeks, and the San Jacinto Valley. The historic specimen information regarding D. m. parvus is under represented in museum collections. This fact is most evident when trying to establish a detailed historic distribution based on limited numbers of specimens in museum collections.

Field survey data included in this report for the San Bernardino kangaroo rat were conducted between 1987 and 1996. These surveys covered all historical locations to varying degrees. Those areas such as Santa Ana Wash, Cajon Wash, Lytle Wash, Etiwanda alluvial fan watershed, City Creek, the southern edge of the town of Bloomington, and San Jacinto River near Hemet were extensively surveyed. While other locations such as Ontario, Loma Linda, Reche Canyon, Colton were trapped less frequently because of the conspicuous land conversion of suitable habitats.

Two procedures were used for establishing whether or not SBKR occupied habitat. The first procedure incorporated sampling using Sherman live-traps configured in 10m by 10m (100 traps/ha) trapping grids. Trapping grids were run for three consecutive

nights. Captured SBKR were sexed, aged (adult/juvenile), examined as to reproductive status (scrotal/lactating), marked and released. Proportions of marked to unmarked SBKR captured on the third trap morning were used to estimate SBKR densities per hectare (Jolly 1965). Forty, one hectare grids were utilized between 1987 and 1996. The second procedure incorporated an assessment line array which consisted of 2 parallel lines 750 meters in length and 30 meters apart with 1 Sherman live-trap per station every 10 m which provided a 150 trap assessment per trap night. This procedure was used to determine presence/absence on a given night. These assessment lines were conducted only once per night per trap site. Approximately 60,000 trap-nights have been conducted within the range of the SBKR using this procedure.

Habitat occupation was determine by mapping similarity of habitat through the initial trapping determination. This determination was used in fluvial systems which contained the preferred habitat for SBKR. We did not include burrow counts as in other Dipodomys spp. studies (O'Farrell and Uptain 1989). Within most occupied habitats of SBKR, the Pacific kangaroo rat (D. agilis) coexists with SBKR. Although these two Heteromyids usually prefer different substrates (McKernan, unpublished data), a overlap zone does occur in most alluvial scrub habitats. Because of potential errors in estimating SBKR occupied habitat through burrow counts other methods were used to determine occupied habitat.

To evaluate suitable and potentially occupied habitat, qualitative vegetation sampling was used to define what was suitable habitat criteria based on substrate and vegetation cover

estimates. To formulate the vegetation and substrate affinities for SBKR a releve measure was used during the placement of the traps (Mueller-Dombois and Ellenberg 1974). Substrate within one square meter, centered on each trap was scored for percent cover of fine sand <1mm, cobble > 1mm < 2cm, cobble > 2cm < 5cm, cobble > 5cm < 15cm, and boulders > 15 cm. A releve for vegetation within a 10m diameter circle, centered on each trap was scored for percent annual cover, and perennial cover.

A preliminary Goodness-of-fit analysis of captured SBKR and Pacific Kangaroo rat (Dipodomys agilis) using habitat and substrate variables was analyzed. These data were used to evaluate micro-habitat distinctions between the two species.

RESULTS AND DISCUSSION

Distribution

The type locality for the San Bernardino kangaroo rat is Reche Canyon, San Bernardino County, 4 miles southeast of Colton (Figure 3). The first specimen was collected on 12 June 1892 by R.B. Herron (no. 8213, adult female, deposited at Academy of Natural Science, Philadelphia, PA.). The current distribution of the San Bernardino kangaroo rat is almost completely isolated from the range of the other two subspecies. Although, an area along the southeastern edge of D. merriami parvus distribution near Diamond Valley and Bautista Canyon, south of Hemet, Riverside County could be an area of intergrade with D. merriami collinus (Lidicker 1960, Hall 1981). This intergrade may have been along Temecula Creek north through Murrieta Hot Springs, Riverside County. The nominate D. merriami merriami does occur

Known status and distribution for D. merriami parvus

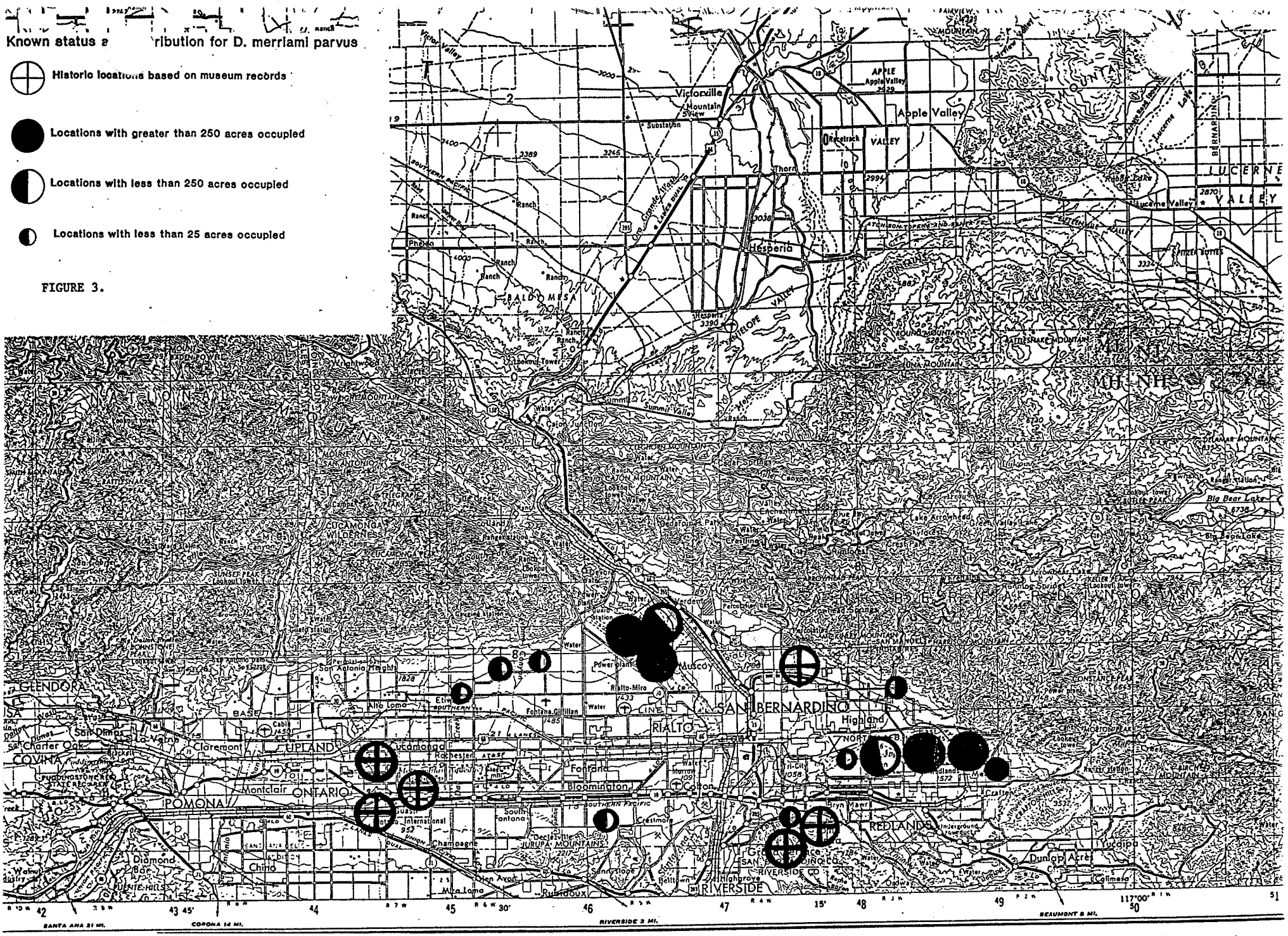
Historic locations based on museum records

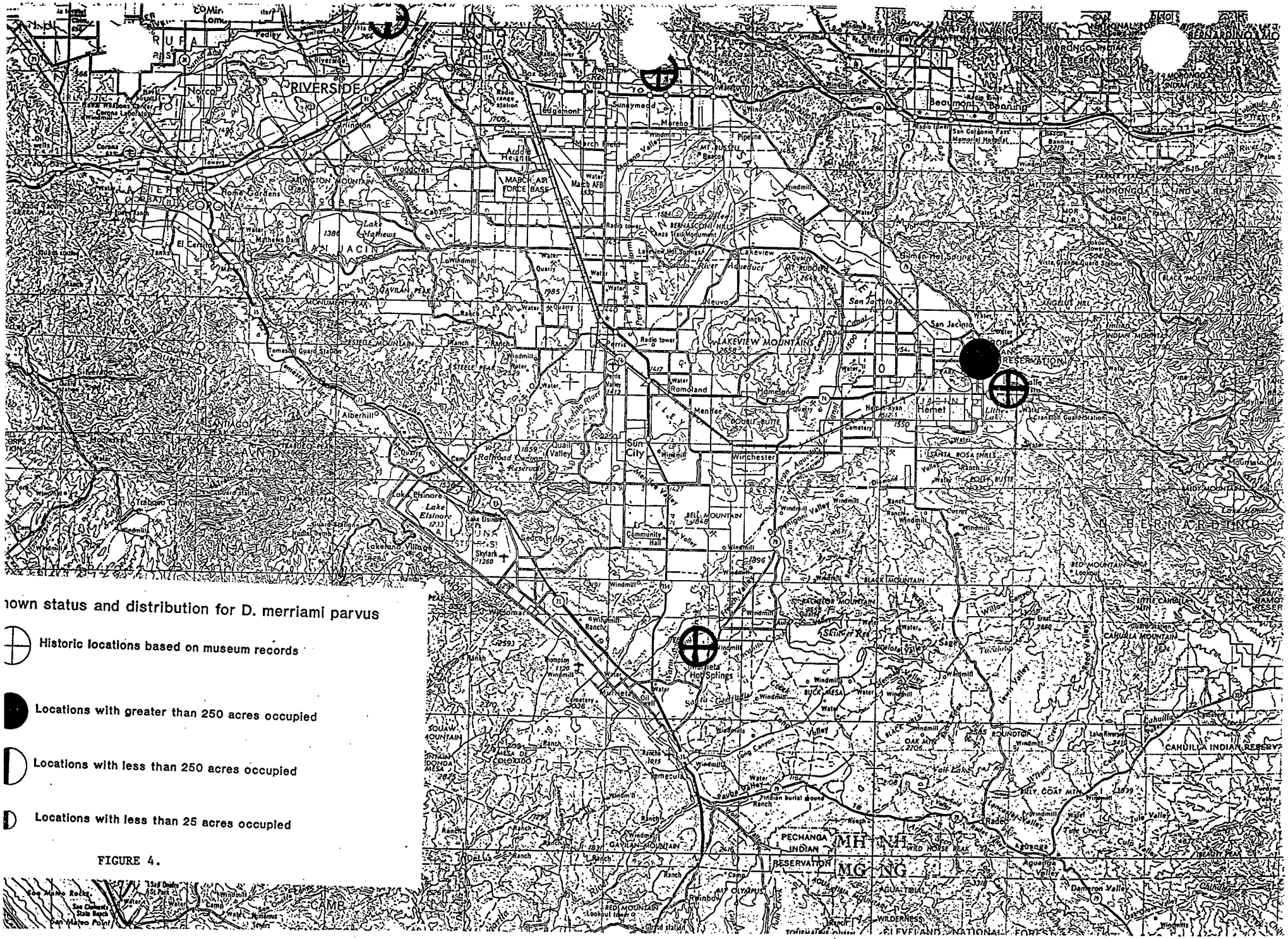
Locations with greater than 250 acres occupied

Locations with less than 250 acres occupied

Locations with less than 25 acres occupied

FIGURE 3.





own status and distribution for D. merriami parvus

Historic locations based on museum records

Locations with greater than 250 acres occupied

Locations with less than 250 acres occupied

Locations with less than 25 acres occupied

FIGURE 4.

in the northern and central portions the Cajon Pass, San Bernardino County. Although, the nominate and D. m. parvus are allopatric within the Cajon Pass and are currently separated by approximate 8 to 10 kilometers (km).

The historical range of D. merriami parvus extended from the San Bernardino and San Jacinto valleys from Cajon Wash north of San Bernardino to Valle vista and Menifee Valley in Riverside County (Lidicker 1960, Hall 1991, McKernan 1993).

Based on the results of approximately 60,000 trap nights the San Bernardino kangaroo rat is currently found at 8 locations, 7 in San Bernardino Valley, San Bernardino County, and 1 along the San Jacinto River, Riverside County (Figure 3 and 4). The locations vary in suitable habitat and relative abundances. The San Bernardino Valley locations include the Santa Ana River Wash in the vicinity of Highland and Redlands. The Santa Ana River currently contains the bulk of the most suitable habitat remaining in the subspecies range. The Cajon and Lytle Creeks near Devore are two AFSS locations which contain large blocks of suitable habitat for SBKR. Trapping data and aerial mapping data show the Santa Ana Wash and Cajon and Lytle Washes having the largest concentration of SBKR within its remaining range.

SAN BERNARDINO COUNTY.

Historic occurrence based on specimens: Highland (SBCM); Reche Canyon (MVZ); Ontario (LACMNH).

San Bernardino Valley

Known occurrence for SBKR follows unit codes found in Table 2.

Lytle Creek; (DE8) USGS Devore Quadrangle, T.1.N, R.5.W, section 8. The east side of Lytle Creek wash in the vicinity of

Table 2. The proximate status and distribution of SBKR over its known range.

USGS Quadrangle	Township	Range	1/4 of NE	1/4 of NW	1/4 of SE	1/4 of SW	Section	Unit*
Redlands	T.1.S	R.3.W	x(1)			x(1)	4	CC4
Redlands	T.1.S	R.3.W	x(2)		x(3)	x(3)	8	SAR8
Redlands	T.1.S	R.3.W	x(2)	x(2)	x(3)	x(3)	9	SAR9
Redlands	T.1.S	R.3.W	x(3)	x(3)	x(3)	x(3)	10	SAR10
Redalnds	T.1.S	R.3.W	x(2)	x(3)	x(3)	x(2)	11	SAR11
Redlands	T.1.S	R.3.W	x(2)	x(3)	x(3)	x(3)	12	SAR12
Redlands	T.1.S	R.3.W	x(2)	x(2)	x(3)	x(3)	7	SAR7
Redlands	T.1.S	R.3.W		x(1)			16	SAR16
Redlands	T.1.S	R.3.W	x(3)	x(4)			15	SAR15
Redlands	T.1.S	R.3.W	x(4)	x(4)			14	SAR14
Redlands	T.1.S	R.3.W	x(4)	x(3)			13	SAR13
Harrison Mtn.	T.1.N	R.3.W		x(1)			30	HM30
Harrison Mtn.	T.1.N	R.3.W				x(1)	34	HM34
Cucamonga Peak	T.1.N	R.6.W	x(1)				28	CP28
Cucamonga Peak	T.1.N	R.6.W			x(1)		21	CP21
Cucamonga Peak	T.1.N	R.6.W	x(1)				31	CP31
Fontana	T.1.S	R.6.W		x(1)			35	FO35
Fontana	T.1.S	R.6.W		x(1)			3	FO3
Fontana	T.1.S	R.6.W		x(1)			33	FO33
Devore	T.1.N	R.5.W	x(2)	x(3)	x(2)	x(2)	8	DE8
Devore	T.1.N	R.5.W	x(3)				17	DE17
Devore	T.1.N	R.5.W	x(3)	x(2)	x(3)	x(3)	16	DE16

Table 2. The proximate status and distribution of SBKR over its known range

USGS Quadrangle	Township	Range	1/4 of NE	1/4 of NW	1/4 of SE	1/4 of SW	Section	Unit*
Devore	T.1.N	R.5.W	x(2)				3	DE3
Devore	T.1.N	R.5.W	x(3)	x(2)			21	DE21
Devore	T.1.N	R.5.W		x(2)		x(2)	8	DE8
Devore	T.1.N	R.5.W	x(2)		x(2)		10	DE10
Devore	T.1.N	R.5.W	x(3)	x(2)	x(2)		33	DE33
Devore	T.1.N	R.5.W		x(2)	x(2)		29	DE29
San Bernardino,N.	T.1.N	R.5.W	x(1)		x(1)		26	SBN26
San Bernardino,N.	T.1.N	R.5.W	x(2)	x(3)	x(2)	x(2)	20	SBN20
San Bernardino,N.	T.1.N	R.5.W	x(2)	x(2)	x(2)	x(2)	14	SBN14
San Bernardino,N.	T.1.N	R.5.W				x(1)	6	SBN6
San Bernardino,S.	T.1.S	R.4.W	x(1)				34	SBS34
Guasti	T.1.N	R.6.W			x(1)		20	GU20
Guasti	T.1.N	R.6.W			x(1)		29	GU29
Yucaipa	T.1.S	R.2.W		x(1)			21	YU21
Yucaipa	T.1.S	R.2.W				x(1)	16	YU16
Yucapia	T.1.S	R.2.W	x(2)	x(2)	x(1)	x(1)	17	YU17
Yucapia	T.1.S	R.2.W	x(2)	x(2)	x(1)	x(4)	8	YU8
San Jacinto	T.5.S	R.1.E	x(1)	x(2)	x(2)	x(2)	5	SJ5
San Jacinto	T.4.S	R.1.W			x(1)		6	SJ6
San Jacinto	T.4.S	R.1.W			x(2)	x(2)	4	SJ4
San Jacinto	T.4.S	R.1.W		x(3)	x(1)		9	SJ9
Blackburn	T.4.S	R.1.W	x(1)	x(1)			10	BB10
Flumor	T.4.S	R.1.W				x(1)	3	FL3

(#) indicates approximate amount of potential occupied SBKR habitat within each quarter section; 1 = 0-25%, 2 = 26-50%, 3 = 51-75%, 4 = 76 - 100%.

Interstate 15 has a considerable amount of pioneer and intermediate phase AFSS. The wash complex in this area has a active fluvial system with very little infrastructure to obstruct flow. The SBKR reach their highest relative abundance in the northwest portion of section 8 (Table 2).

Lytle Creek; (DE17) USGS Devore Quadrangle, T.1.N, R.5.W, section 17. Within section 17 along the western edge of Lytle Creek there are a series of water diversion dikes which have isolated the AFSS and created a more mature AFSS habitat. This change to a mature phase of AFSS has reduced SBKR distribution in this area. The northeast portion of section 17 still contains a moderate to high relative abundance of SBKR (Table 2).

Lytle Creek; (DE16) USGS Devore Quadrangle, T.1.N, R.5.W, section 16. This portion of Lytle Creek wash within section 16 retains a fairly moderate to high relative abundance of SBKR. Although, because of sand and gravel mining and water diversion dikes the functioning floodplain is greatly diminished. Through the restriction of fluvial action by these activities the immediate downstream occupied SBKR habitat has been reduced through the maturity of AFSS (Table 2).

Cajon Wash;(DE3) USGS Devore Quadrangle, T.1.N, R.5.W, section 3. The Cajon Wash within section 3 has occupied habitat within its northeast portion. Due to the pioneer and intermediate phases of the AFSS within this area of the Cajon Wash, SBKR relative abundance is high in the central portion of the wash, while the upper terraces have mostly low abundances. This portion of the Cajon Wash has a considerable amount of infrastructure development which has diminished the AFSS quality and reduced the

suitable habitat for SBKR (Table 2).

Lytle Creek; (DE21) USGS Devore Quadrangle, T.1.N, R.5.W, section 21. The northwest and northeast portion of section 21 contains some undisturbed AFSS habitat. The SBKR occurs in low to moderate abundance in this area. The northwest portion contains very little suitable habitat, however prior to infrastructure development, such as at Riverside Avenue and the associated flood control dikes, this area contained a considerable amount of occupied SBKR habitat. At one time this area was part of the active Lytle Creek floodplain. Presently this area accommodates low numbers of SBKR usually adjacent to the sand and gravel operations in the historic abraided wash channels (Table 2).

Cajon Creek; (DE10) USGS Devore Quadrangle, T.1.N, R.5.W, section 10. This portion of Cajon Creek in section 10 contains moderate to high relative abundances of SBKR. Although, this reach of the Cajon Creek has continuing impacts due to flood control maintenance and sand and gravel activities. Overall these activities have either modified or reduced the fluvial activities of Cajon Creek by either redirecting or impeding fluvial action (Table 2).

Cajon Creek;(DE33) USGS Devore Quadrangle, T.1.N, R.5.W, section 33. This location is in the vicinity of Devore and Interstate 15. The vicinity of Cajon Wash within the northeast, northwest, and southeast portion of section 33 still contains an active fluvial area and thereby has suitable SBKR habitat. The northwest portion of section 33 which is within the central portion of Cajon Pass has low to moderate abundances of SBKR. Presently within this reach of the Cajon Creek very limited

disturbance exists within the wash corridor. The northeast portion of this section is in the vicinity of Devore. The occupied habitat in this area is restricted to the active wash zone which has pioneer and intermediate phases of AFSS. The relative abundance of SBKR in this area is low, although their are marginal patches of moderate SBKR abundances. The southeast portion of section 33 is adjacent to the San Bernardino County Glen Helen Regional Park. Extensive activities related to park management such as flood control maintenance and infrastructure for the Regional Park has modified the fluvial system along this portion of the Cajon Creek. This area contains low to moderate abundances of SBKR outside of the barren creek channel among the adjacent AFSS (Table 2).

Cajon Creek; (DE29) USGS Devore Quadrangle, T.1.N, R.5.W, section 29. Section 29 includes portions of the Cajon Pass and is located in the vicinity of the northern limits of the SBKR distributional range. Within the Cajon Wash there are narrow AFSS benches which retain low to moderate abundances of SBKR. This portion of the Cajon Wash is fairly pristine relative to infrastructure developments, although recreational use can be excessive (Table 2).

Lytle Creek Wash; (SBN26) USGS San Bernardino, North Quadrangle, T.1.N, R.5.W, section 26. Within the northeast portion of section 26 SBKR occupy the AFSS which borders Lytle Creek. Encroachment of flood control activities has modified the fluvial pattern of the wash. The AFSS consist of narrow fragmented benches which contain low relative abundances of SBKR. The southeast portion of the section 26 is similar to the northeast

portion, although occupied habitat is reduced along this portion of Lytle Creek Wash and had low relative abundances of SBKR (Table 2).

Lytle Creek Wash; (SBN20) USGS San Bernardino, North Quadrangle, T.1.N, R.5.W, section 20. This portion of the Lytle Creek Wash has a considerable amount of SBKR occupied habitat. The AFSS in this area is mostly pioneer phase and contains a moderate relative abundance of SBKR. The primary risk to this occupied habitat is from sand and gravel operations (Table 2).

Cajon Wash; (SBN14) USGS San Bernardino, North Quadrangle, T.1.N, R.5.W, section 14. This portion of the Cajon Wash has a low to moderate relative abundance of SBKR. Within this section there are impacts on SBKR habitat due to infrastructure (roads, rail lines, flood control dikes, bridges, etc.) within the Cajon Wash which has influenced the fluvial system (Table 2).

Cajon Wash; (SBN6) USGS San Bernardino, North Quadrangle, T.1.N, R.5.W, section 6. This portion of the Cajon Wash contains a small amount of SBKR occupied habitat. Various types of infrastructure (roads, bridges, flood control dikes, etc.) are located within this area of the wash which creates incidental impacts to occupied SBKR habitat by altering fluvial patterns (Table 2).

Reche Canyon; (SBS34) USGS San Bernardino, South Quadrangle, T.1 S., R 4 W., section 34. The northern portion of Reche Canyon is the type locality for the D. merriami parvus. Historically the SBKR occupied a extensive area within the sandy wash habitats of Reche Canyon. As late as 1988 two locations in section 34 contained SBKR occupied habitat. However, urban development and

flood control activities at the northern terminus of the canyon eliminated one of the two SBKR populations. Occupied habitat currently exists in the northwest portion of section 34. In 1993 SBKR still occupied this location, however the viability of this population is in question based on the recent residential development, flood control activities, and increases in infrastructure within the northern portion of the Reche Canyon. The relative abundance for the Reche Canyon SBKR population is small with little change since 1988 (Table 2).

Etiwanda Avenue; (GU20) USGS GUASTI, Quadrangle, T.1.N, R.6.W, section 20. A small area of disturbed AFSS habitat exist along the East Etiwanda Creek Channel immediately west of Etiwanda Avenue. The channel contains less than 2 acres with low relative abundance of occupied SBKR habitat. This location is subject to a high level of disturbance from various human activities (i.e. flood control, road maintenance, and plowing and tilling for fire abatement). This occupied area is isolated from all other known SBKR populations, the nearest being 5 miles to the northeast (Table 2).

Historic East Etiwanda Creek floodplain; (GU29) USGS GUASTI, Quadrangle, T.1.N, R.6.W, section 29. Only a remnant amount of occupied AFSS habitat (less than 2 acres) remains in this area. The relative abundance is low at this location (Table 2).

Southern edge of Mill Creek; (YU21) USGS YUCAIPA, Quadrangle, T.1.S R.2.W, section 21. The northwest portion of this section extends into the southern edge of the Mill Creek floodplain. Narrow fragments of AFSS currently exist with relatively low abundances of SBKR. A considerable amount of disturbance by

flood control activities and infrastructure has created a precarious situation for SBKR in this area (Table 2).

Northern edge of Mill Creek; (YU16) USGS YUCAIPA, Quadrangle, T.1.S R.2.W, section 16. The southern edge of section 16 includes a portion of the Mill Creek floodplain. Occupied SBKR habitat exist along the southwest corner of this section. This location contains remnant AFSS primarily the intermediate phase. The SBKR relative abundance is low along this reach of Mill Creek. The AFSS is disturbed in this area by flood control activities and recreational uses (Table 2).

Northern edge of Mill Creek; (YU17) USGS YUCAIPA, Quadrangle, T.1.S R.2.W, section 17. This area is near the confluence of Mill Creek and the Santa Ana Wash. Section 17 contains a considerable amount of SBKR occupied habitat. The AFSS is diverse within the floodplain of Mill Creek. In section 17 all three phases of AFSS are present, pioneer, intermediate, and mature. As expected SBKR reach their greatest relative abundance in the AFSS pioneer and intermediate phases at the confluence of Mill Creek and Santa Ana Wash. Occupied habitat in this area is complex with a series of narrow channels of pioneer AFSS bisecting mature areas of AFSS. At the northwestern end of section 17 the greatest amount of occupied SBKR habitat occurs. Disturbances within section 17 are mainly confined to the southern half associated with the San Bernardino Water Conservation District percolation basins. However, occupied habitat has persisted on the borders of these percolation basins (Table 2).

Northern edge of Mill Creek; (YU8) USGS YUCAIPA, Quadrangle, T.1.S R.2.W, section 8. The majority of section 8 covers a portion of Santa Ana Wash. Within this section all three AFSS phases are represented. The central and southern portion of this area contains the highest relative abundance of occupied SBKR habitat which ranges from moderate to high. The northern half of this section which contains the San Bernardino Water Conservation District percolation basins has occupied SBKR habitat. The relative abundance in this area is low to moderate. The SBKR occupied habitat includes the margins of the basins and in some cases those basins which have not been used for some duration. The areas which have AFSS present in the percolation basins have low abundances of SBKR (Table 2).

Portions of City Creek; (RE4) USGS REDLANDS, Quadrangle, T.1.S R.3.W, section 4. Only the northeast and southwest portions of this section have occupied SBKR habitat. The occupied habitat is confined to the City Creek Channel and the percolation basins within the channel. Within the City Creek channel there is AFSS which is represented by both pioneer and intermediate phases. The occupied SBKR habitats have a low relative abundance at this location (Table 2).

Santa Ana Wash near Norton Air Force Base; (RE8) USGS REDLANDS, Quadrangle, T.1.S R.3.W, section 8. Historically most of section 8 was occupied SBKR habitat. Currently most AFSS in this portion of the Santa Ana Wash has either been removed or disturbed. However, their is enduring SBKR habitats within the northwest, southwest, and southeast portions of section 8. Various types of

infrastructure have diverted or halted fluvial action of the Santa Ana Wash in this area and ultimately will reduce the quality and quantity of AFSS. Most of the SBKR habitat in this area is fragmented and isolated. The relative abundances for SBKR range from low to moderate in section 8 (Table 2).

Santa Ana Wash east of Alabama Street; (RE9) USGS REDLANDS, Quadrangle, T.1.S R.3.W, section 9. Although this portion of the Santa Ana Wash contains extensive areas of occupied SBKR habitat there are sizable sand and gravel operations which have diminished large tracts of AFSS. The main location of land conversion is in the central portion of section 9. The southwest and southeast portions of section 9 contain the most contiguous areas of occupied SBKR habitat. This southern location has moderate to high SBKR relative abundances. In addition, these areas do encounter some fluvial action however it is from secondary runoff and usually does not originate from the Santa Ana River. The northern portion of section 9 has a substantial amount of disturbance to AFSS habitats. However, along the Plunge Creek Channel there is occupied SBKR habitat which has a low to moderate relative abundances (Table 2).

Santa Ana Wash which is bisected by Orange Street; (RE10) USGS REDLANDS, Quadrangle, T.1.S R.3.W, section 10. Section 10 has similar attributes as section 9. Within section 10 there is extensive sand and gravel operations which occur primarily in the central portion of the section. In both the northern and southern portions of section 10, SBKR occupied habitat exist in moderate to high relative abundances (Table 2).

Santa Ana Wash east of Church Street; (RE11) USGS REDLANDS, Quadrangle, T.1.S R.3.W, section 11. This section contains large sand and gravel operations. These sand and gravel operations are primarily located in the western portion of section 11. The sand and gravel operation and their associated infrastructure has removed over 150 acres of AFSS habitat which included a considerable amount of occupied SBKR habitat. The remaining occupied habitat in this section has a wide range of relative abundances, however, most occupied habitat has moderate abundance. The only exception to this is along Plunge Creek within section 11 where the relative abundance for SBKR is generally high (Table 2).

Santa Ana Wash east of Church Street; (RE12) USGS REDLANDS, Quadrangle, T.1.S R.3.W, section 12. Within this portion of the Santa Ana Wash there are no existing sand and gravel operations and very little infrastructure (roads, bridges, flood control systems, etc.). The northern portion of section 12 has a considerable amount of mature AFSS as well as components of chaparral phase vegetation. These two plant community types are usually found along old terraces and benches which usually do not contain occupied SBKR habitat. Although, there are a series of east-west abraided channels which bisect these older benches and do contain moderate relative abundances of SBKR. Within the southern portion of section 12 there is a greater amount of pioneer and intermediate phases of AFSS which contain more occupied SBKR habitat with some areas having high relative abundances especially along the old rail grade (Table 2).

Santa Ana Wash east of Church Street; (RE7) USGS REDLANDS, Quadrangle, T.1.S R.3.W, section 7. Within this section there are several retention basins which have created a more stabilized and mature AFSS community. This is apparent in the northern portion of section 7. Similar to section 12, there are east-west abraided channels which have occupied SBKR habitats. These east-west channels are not as extensive as those in section 12 and they contain low abundances of SBKR. The southern portion of this section within the active floodplain of the Santa Ana River contains large tracts of pioneer and intermediate phase AFSS. These large tracts of AFSS have moderate to high SBKR relative abundances (Table 2).

Along the southern edge of the Santa Ana Wash; (RE16) USGS REDLANDS, Quadrangle, T.1.S R.3.W, section 16. The only portion of this section which has occupied SBKR habitat is along its extreme northern boundary. A narrow portion of AFSS habitat exists along the southern edge of the Santa Ana Wash. The AFSS in this area is generally pioneer phase. The occupied habitat in this area is precarious based on its location relative to Highway 30. The highway bridge deters fluvial action of the Santa Ana River thereby isolating and reducing the quality of this occupied SBKR habitat (Table 2).

Along the southern edge of the Santa Ana Wash; (RE15) USGS REDLANDS, Quadrangle, T.1.S, R.3.W, section 15. The northern half of this section has a considerable amount of SBKR occupied habitat. Orange Street separates this section north to south with the northwest and northeast sides of Orange Street containing substantial SBKR habitat existing in both pioneer and

intermediate phases of AFSS. The relative abundance for SBKR in this area is considered to be low to moderate. Sand and gravel operations are present within the northeast portion of this section. Along with sand and gravel activity other disturbances occur within occupied habitat usually as flood control mainatance and off-road vehicle activity (Table 2).

Along the southern edge of the Santa Ana Wash; (RE14) USGS REDLANDS, Quadrangle, T.1.S, R.3.W, section 14. Within section 14 all SBKR habitat exists in the northern portion. The AFSS is mainly pioneer and intermediate phase with SBKR occurring in moderate to high relative abundances. The AFSS just north of the Santa Ana River bed is noteworthy for the relatively high concentration of SBKR. The main disturbance activities are centered in the northwest portion of this section and are related to sand and gravel activities and their infrastructure (Table 2).

Along the southern edge of the Santa Ana Wash; (RE13) USGS REDLANDS, Quadrangle, T.1.S, R.3.W, section 13. Comparable to the two previously mentioned sections the occupied SBKR habitat occurs within the northern portion of section 14. The AFSS north of the Redlands Municipal Airport is generally pioneer and intermediate phases, however, some mature forms of AFSS do exist in this area. For those pioneer and intermediate areas, SBKR occurs in moderate to high relative abundances. Very limited disturbances exist in the northern portion of section 14 within SBKR habitat. However, some secondary disturbances do exist due to SBWCD activities (Table 2).

Sand Creek Channel area; (HM30) USGS HARRISON MTN., Quadrangle, T.1.N, R.3.W, section 30. Along the western edge of Sand Creek

flood control channel a remnant piece of SBKR habitat existed in the late 1980's. However, based on flood control activities this occupation was very precarious then and is almost surely vanished because of these activities. During the late 1980's relative abundance was low and limited to less than 1 acre (Table 2).

City Creek Channel area; (HM34) USGS HARRISON MTN., Quadrangle, T.1.N, R.3.W, section 34. The SBKR occupied habitat exist only in the managed floodplain of City Creek. Remnant AFSS still exist within this portion of the City Creek channel in section 34 and the occupied SBKR habitat in this area is considered a low relative abundance. Currently the AFSS within the City Creek Channel, is very vulnerable either due to the narrow width of this channel which usually confines seasonal flooding events and thereby submerging the occupied habitat, or to the continuing flood control activities (Table 2).

East Etiwanda Creek; (CP28) USGS CUCAMONGA PEAK, Quadrangle, T.1.N, R.6.W, section 28. The northeast portion of this section within the floodplain of East Etiwanda Creek contains a remnant patch of SBKR occupied AFSS habitat. As a result of flood control activities and existing infrastructure which has modified the fluvial system, this occupied habitat has a uncertain future. The relative abundance at this location is low (Table 2).

East Etiwanda Creek; (CP21) USGS CUCAMONGA PEAK, Quadrangle, T.1.N, R.6.W, section 21. Along the edges of the retention basins for East Etiwanda Creek, occupied SBKR habitat persist with the relative abundance being low. The ongoing maintenance of these retention basins has most likely caused extirpation of this remnant population of SBKR (Table 2).

West Edge of the Day Creek Channel; (CP31) USGS CUCAMONGA PEAK, Quadrangle, T.1.N, R.6.W, section 31. Immediately south of Highland Avenue along the Day Creek Channel is a small remnant patch of occupied SBKR habitat. Although this population was located in the late 1980's since that time there is a high probability that this occupied habitat no longer exist due to land conversion and its associated infrastructure (Table 2).

Northwest Edge of the Jurupa Mountains; (FO33) USGS FONTANA, Quadrangle, T.1.S, R.5.W, section 33. This remnant patch of once extensive occupied SBKR habitat is at northern base of the Jurupa Mountains. Historically there was pristine sandy soil deposits which arose initially from fluvial actions created by flooding, wind deposits, and normal runoff from northern parts of the San Bernardino Valley. Today through land conversion less than 1 acre currently exist. This small patch of occupied habitat is along edges of fallow fields. The SBKR relative abundance is considered low (Table 2).

Northwest Edge of the Jurupa Mountains; (FO35) USGS FONTANA, Quadrangle, T.1.S, R.5.W, section 35. This isolated patch of SBKR habitat was once part of a fairly extensive sandy area along the base of the Jurupa Mountains. This remnant patch is highly disturbed with a precarious future based on the extensive development in this area. The relative abundance is considered low at this site (Table 2).

RIVERSIDE COUNTY

Historic occurrence based on specimens: San Jacinto Valley (SBCM); Menifee Valley (SBCM); Valle Vista (MVZ); Hemet (LACMNH).

Northwestern and North central Riverside County

Known occurrence for SBKR follows unit codes found in Table 2.

Along the San Jacinto River near the confluence of Bautista Creek; (SJ5) USGS San Jacinto, Quadrangle, T.4.S, R.1.W, section 5. This location once had extensive AFSS habitat. However, through bank stabilization of the San Jacinto River and land conversion for agriculture, only remnant patches of occupied SBKR habitat persist. Section 5 has occupied fragments of AFSS that rarely form contiguous tracts of habitat and frequently these areas are inundated due to the artificially confined nature of the flood plain. In this area SBKR relative abundance is low to moderate (Table 2).

Along the San Jacinto River; (SJ6) USGS San Jacinto, Quadrangle, T.4.S, R.1.W, section 6. The occupied habitat within this section is located in the southeast portion along the San Jacinto River. Very similar to section 5 the occupied habitat in section 6 is also fragmented and usually found in linear strips within the main channel of the San Jacinto River. The relative abundance is low to moderate along this reach of the San Jacinto River (Table 2).

Along the San Jacinto River; (SJ4) USGS San Jacinto, Quadrangle, T.4.S, R.1.W, section 4. The portion of San Jacinto River near the confluence of Indian Creek contained low to moderate relative abundances of SBKR during 1989 and 1990. The current occupation of SBKR is assumed unchanged, although trapping should be done to assure the occurrence at this location. As with all other areas of occupied SBKR habitat within the San Jacinto River the foremost disturbance is related to flood control activities and

the existence of high water levee's which creates confined sheet flooding in the San Jacinto River channel (Table 2).

Along the San Jacinto River; (SJ9) USGS San Jacinto, Quadrangle, T.4.S, R.1.W, section 9. All occupied habitat within this section is confined to the San Jacinto River with similar habitat characteristics and impacts as in other portions of the San Jacinto River. The relative abundance in this section is considered low (Table 2).

Along the San Jacinto River; (BB10) USGS Blackburn, Quadrangle, T.4.S, R.1.W, section 10. Occupied habitat exists in the northwest, southwest, and southeast portions of section 10 along the San Jacinto River. A portion of this population also occurs outside of the active floodplain on an elevated bench. At this location, the subspecies occurs in an encelia dominated coastal sage scrub habitat on sandy soils. The SBKR relative abundance ranges from low to high with most disturbances to this occupied habitat related to flood control activities (Table 2).

Along the San Jacinto River; (FL3) USGS Fulmor, Quadrangle, T.4.S, R.1.W, section 3. The southwest portion of this section has a small patch of SBKR occupied habitat which exists within the San Jacinto River. The relative abundance at this location is low (Table 2).

Historic and Recent Changes to SBKR Habitat

The alluvial fan sage scrub community was once wide spread among the cismontane valleys of southern California. Over the past 50 years approximately 85% of AFSS has been displaced through spreading urbanization (Westman, 1981). The rapid displacement of AFSS in southern San Bernardino and in northwest

Riverside Counties has created permanent change to this unique vegetation community.

This accelerated degradation of AFSS has extirpated sizable blocks of SBKR occupied areas over most of its historic distribution. While the removal through land conversion of AFSS has been the most substantial reason for the loss of SBKR occupied habitat the related infrastructure to maintain these urbanized centers has equally created loss and degradation as well. These infrastructure impacts to AFSS come in a variety of forms; from water management, stream course alteration practices such as dams and dikes for flood control, water percolation and reclamation basins, to water diversion for municipal, and agricultural use, sand and gravel mining, and building of roads and bridges. Through the continued development of these various types of infrastructure, the AFSS has been fragmented or completely altered to the point of surpassing impacts of even catastrophic flood events.

Fluvial environments which are subjected to these alterations typically change the integral dynamics of a wash system. The increase in road, bridges, dikes, sand mining, and water retention basins which are either within the wash or bisect the floodplain create extensive effects downstream of the developed infrastructure.

An evaluation of historic conditions within two major centers for SBKR distribution provides prime examples of these changes relative to infrastructure. The Santa Ana Wash floodplain currently accommodates one of two locations which has the largest and most contiguous populations of SBKR known.

However, over the past 50 years the continued development of various types of infrastructure within this floodplain has created major alterations to the Santa Ana Wash fluvial system. A comparison of aerial photographs from 1930 with photo's from 1993 provides an excellent example of what so called secondary effects (infrastructure) can have on shaping this fluvial system (Figure 5 and 6). The 1930 photographs illustrate a more active system with a multitude of abraided washes which occur throughout the entire floodplain. The most recent 1993 photograph indicates a more decadent wash system with extensive areas of mature AFSS (Figure 7). These changes are also apparent in a examination of 1930 aerial photographs from the Lytle Creek and Cajon Wash area. These two fluvial systems during the 1930's exhibited a more active wash network with very little encroachment within these two washes (Figure 8). While the 1993 aerial photographs illustrate large segments of these washes which either have been removed from fluvial action all together or through the reduction of water flows have stabilized the AFSS relative to succession (Figure 9). These processes created by infrastructure have diminished SBKR preferred habitat. The SBKR habitat affinities include active wash environments composed of fine sandy soils in relative open wash areas. These attributes are specifically found in AFSS pioneer and intermediate phases of active fluvial systems. Through infrastructure development these early succession vegetation types are transformed into more mature phases of AFSS. This maturity of vegetation brings a more stable substrate with more plant diversity and usually a denser cover of vegetation.

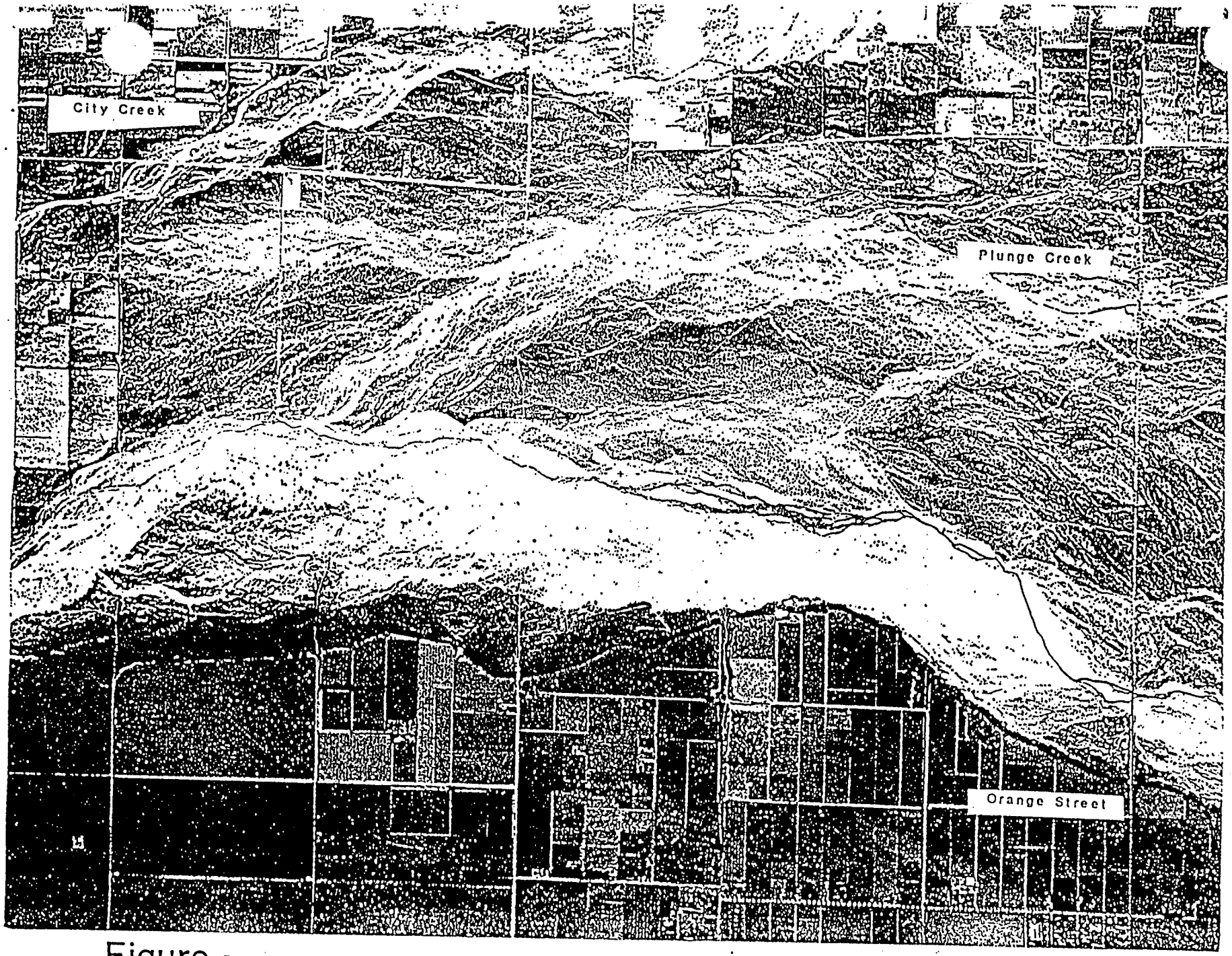


Figure 5.
1930 photograph of the Santa Ana River floodplain indicating the contiguous nature of the alluvial fan landscape

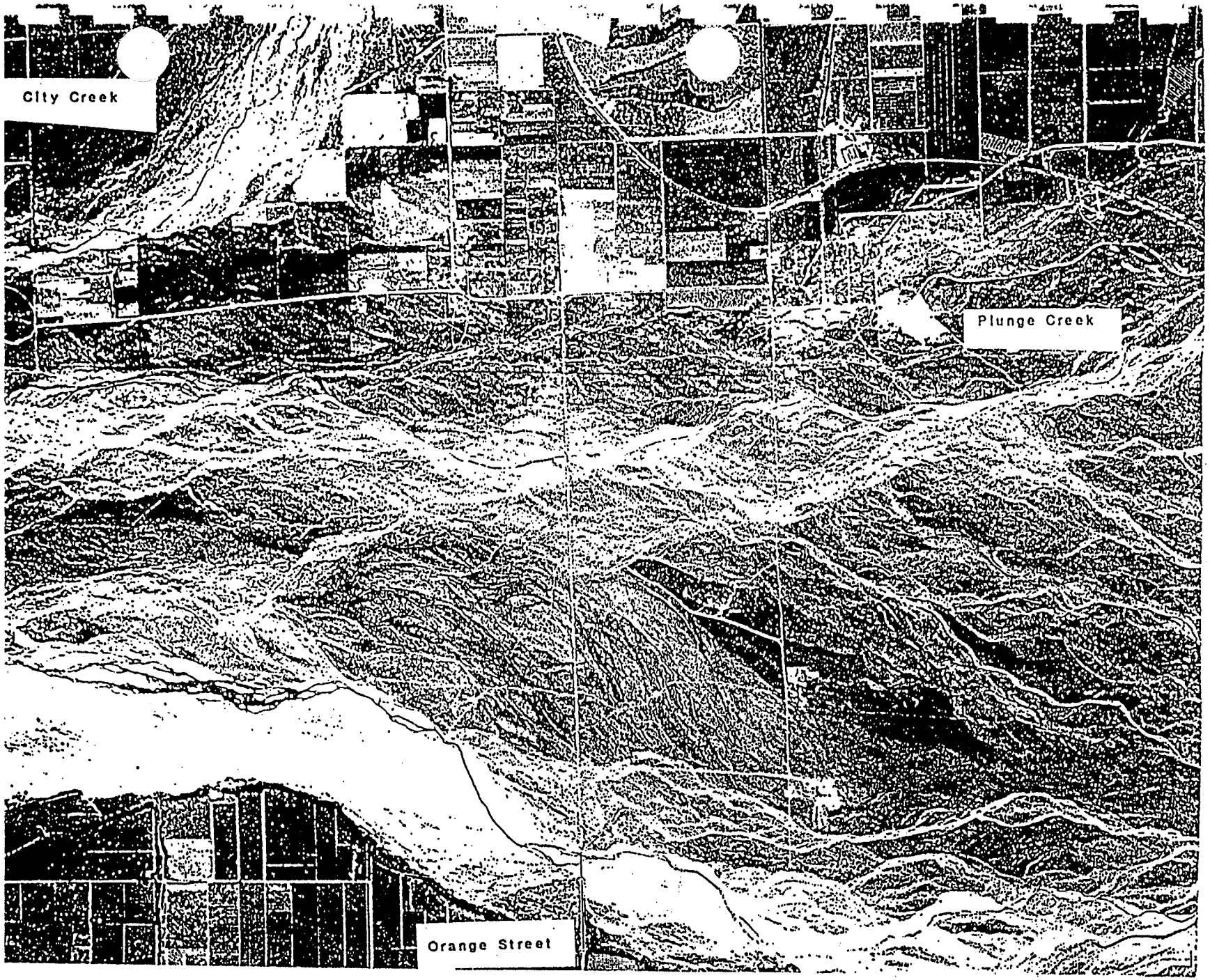
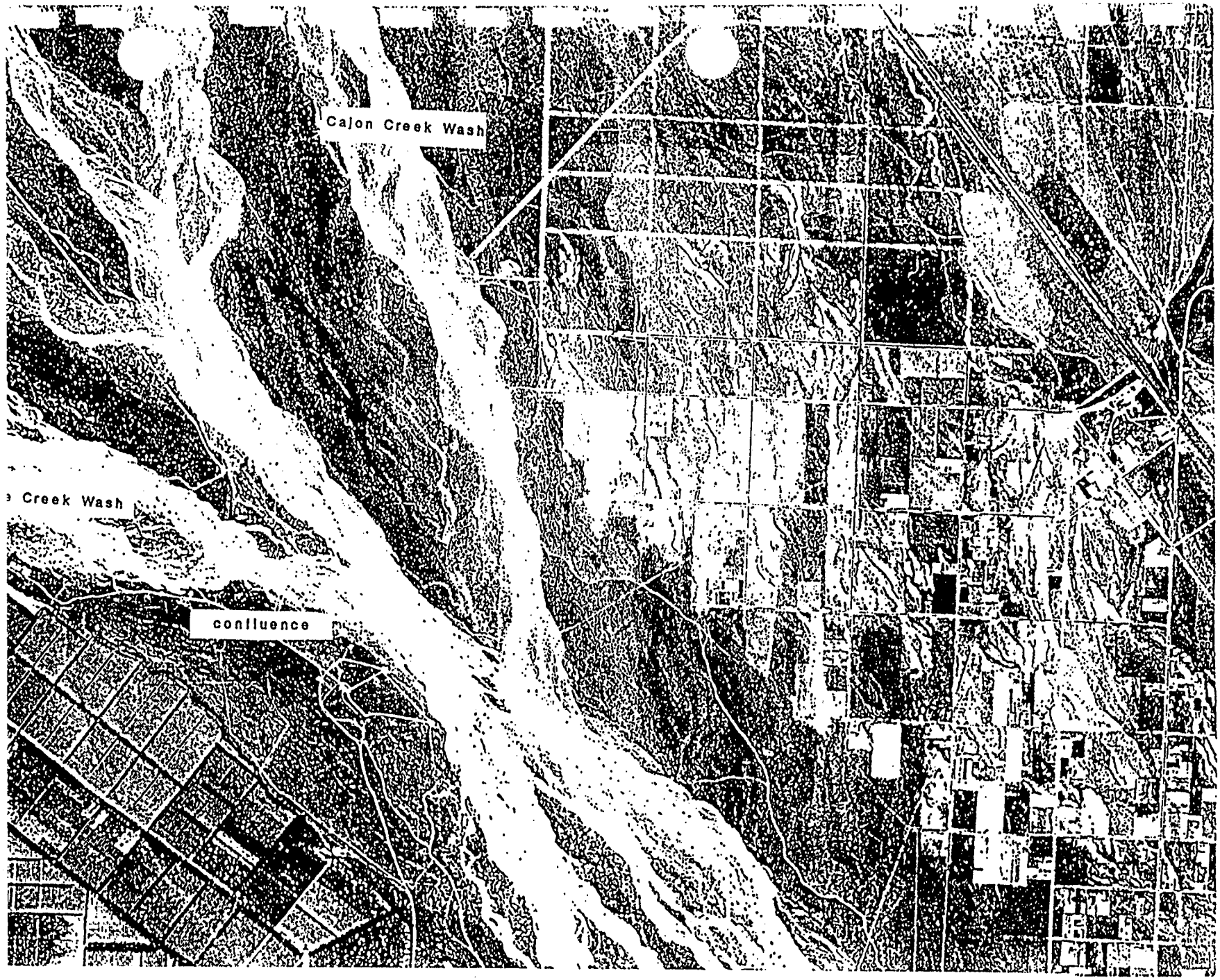


Figure 6.
1930 photograph of the Santa Ana River floodplain indicating the contiguous nature of the alluvial fan landscape

Figure 7. 1993 photograph of Santa Ana River floodplain.



igure 8.
930 aerial photograph of the Cajon Creek and Lytle Creek
onfluence.

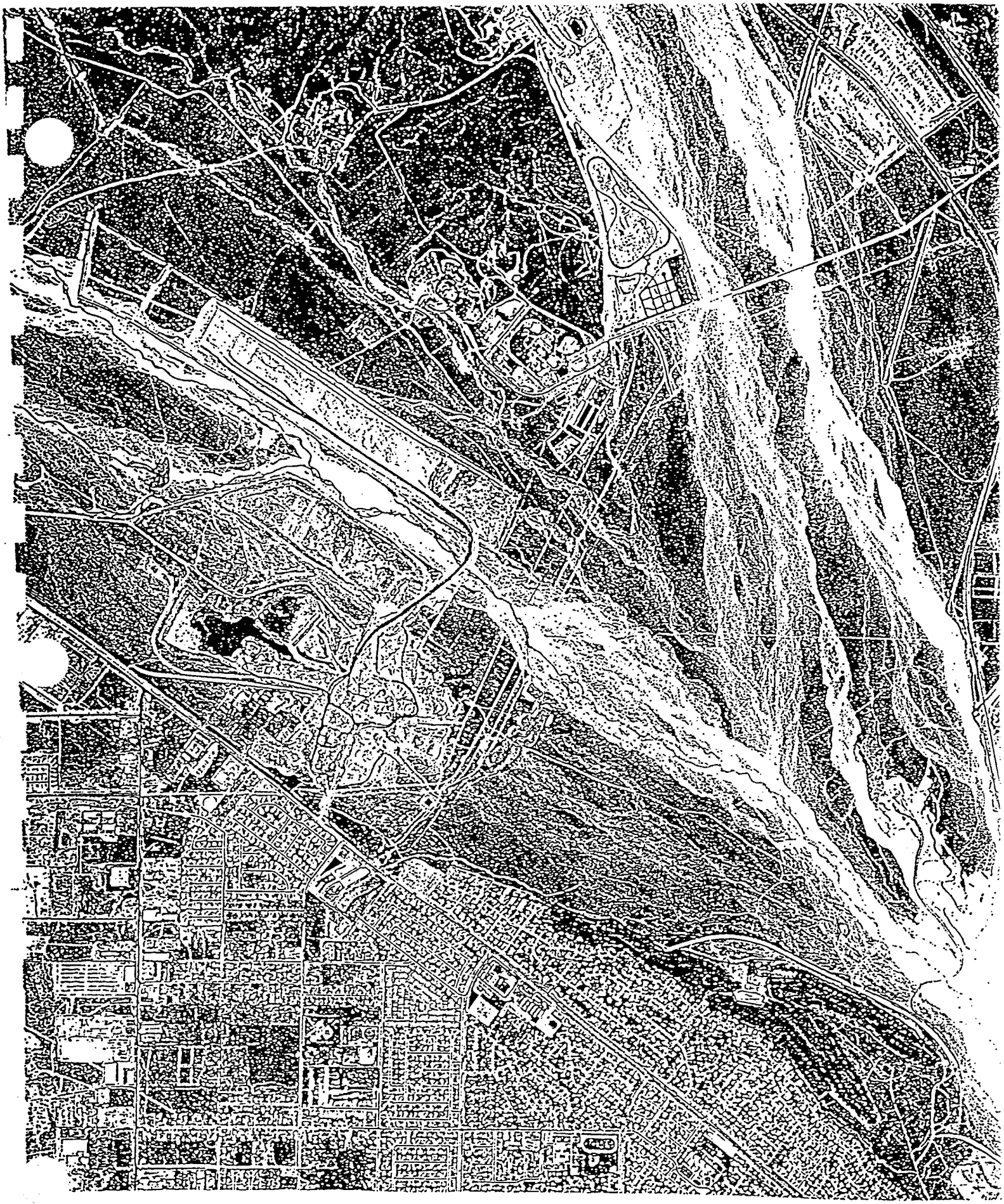


Figure 9. 1993 photograph of Cajon Creek and Lytle Creek confluence.

Substrate and Habitat Affinities for SBKR

The San Bernardino kangaroo rat has specific requirements relative to substrate and habitat affinities (Figure 10). Using 1 hectare trapping grids an assessment was done in Santa Ana Wash and Cajon Creek to evaluate perennial cover, affinity to washes or benches and substrate composition. This releve ranking of soil type, rock fragment size and vegetation cover at each trap station provided insight into habitat selection for SBKR. During trapping events habitat similarity comparisons were also made for the Pacific kangaroo rat (PKR). The PKR can be found coexisting with SBKR in AFSS over most of its range (Figure 11).

Although the sample size is relatively small, PKR was found using the more mature AFSS habitat located with older benches in wash systems (Figure 12). The SBKR generally selected more open AFSS than the PKR (Figure 13).

The microhabitat associations of SBKR usually differ from the PKR in several ways. First, SBKR often shows an affinity for a particular soil texture. Based on the more than 60,000 trap nights a overall impression one obtains from this effort is that SBKR has a strong substrate preference. This preference is for well drained sandy texture soils which can be found in active washes and abraided channels. In addition, these active washes and abraided channels have vegetation cover which ranges from 30 to 50%. This cover preference is most apparent in those abraided channels which appear suitable for SBKR although have been invaded by European annuals. These localities still retain pioneer or intermediate phases of AFSS but the invasion of non-

Figure 10.

Idealized diagram showing SBKR occupied habitat within a fluvial system, braided channels and pioneer phase are usually the centers of the subspecies distribution.

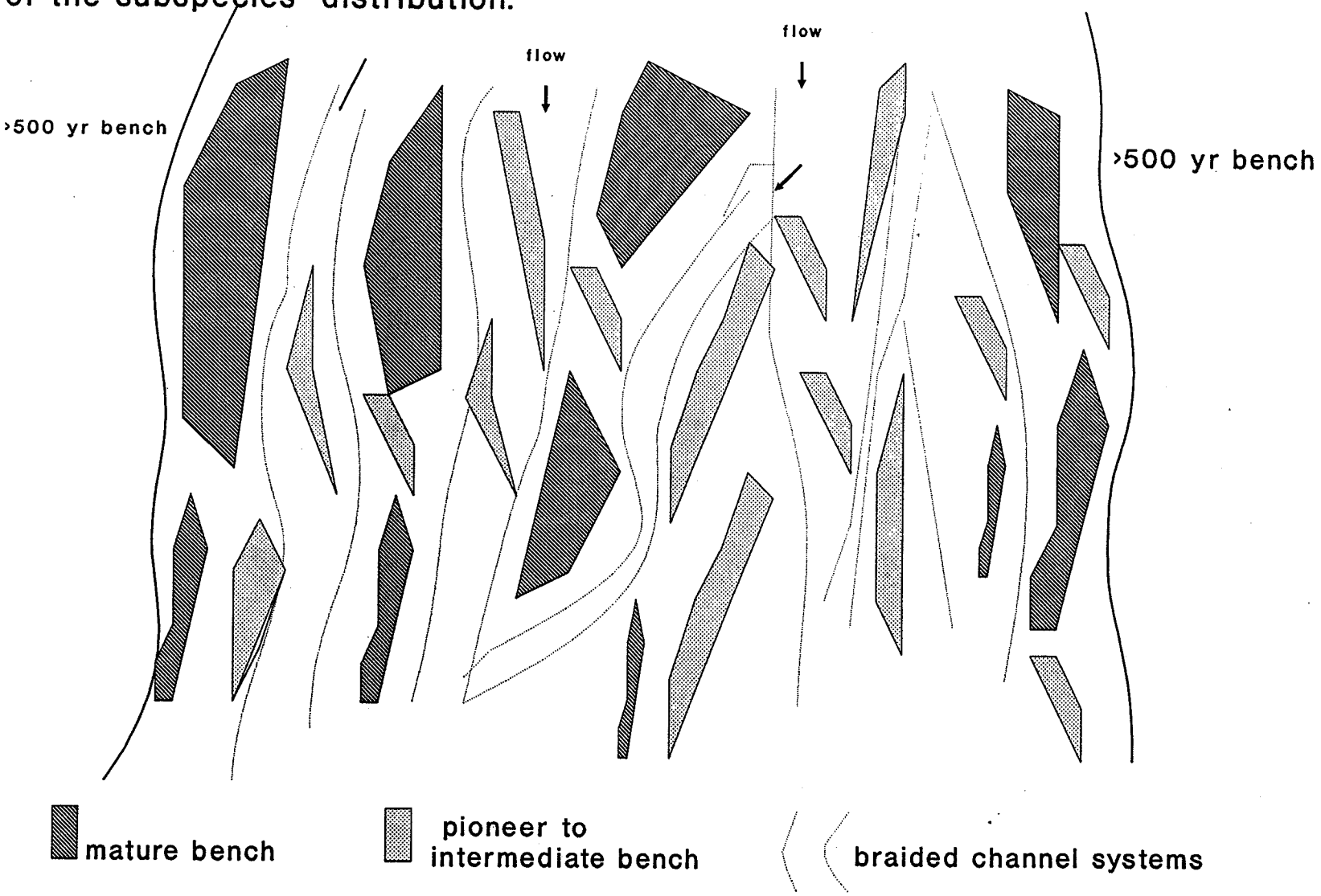


Figure 11.

Habitat preference for SBKR and PKR, sympatry occurs over most of SBKR known range.

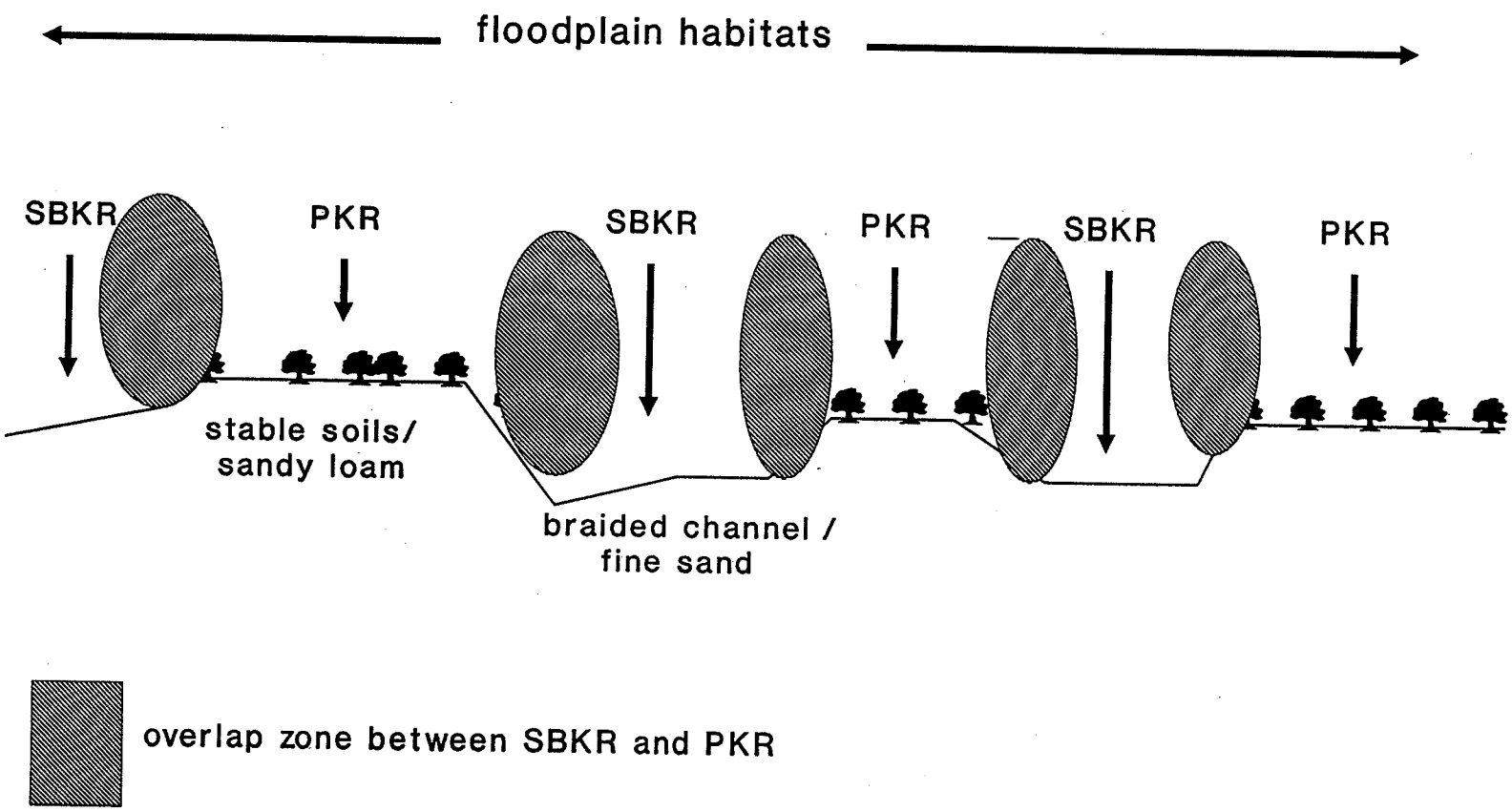


Figure 12.

DIME

	WASH	BENCH
OBS	49	9
EXP	29	29

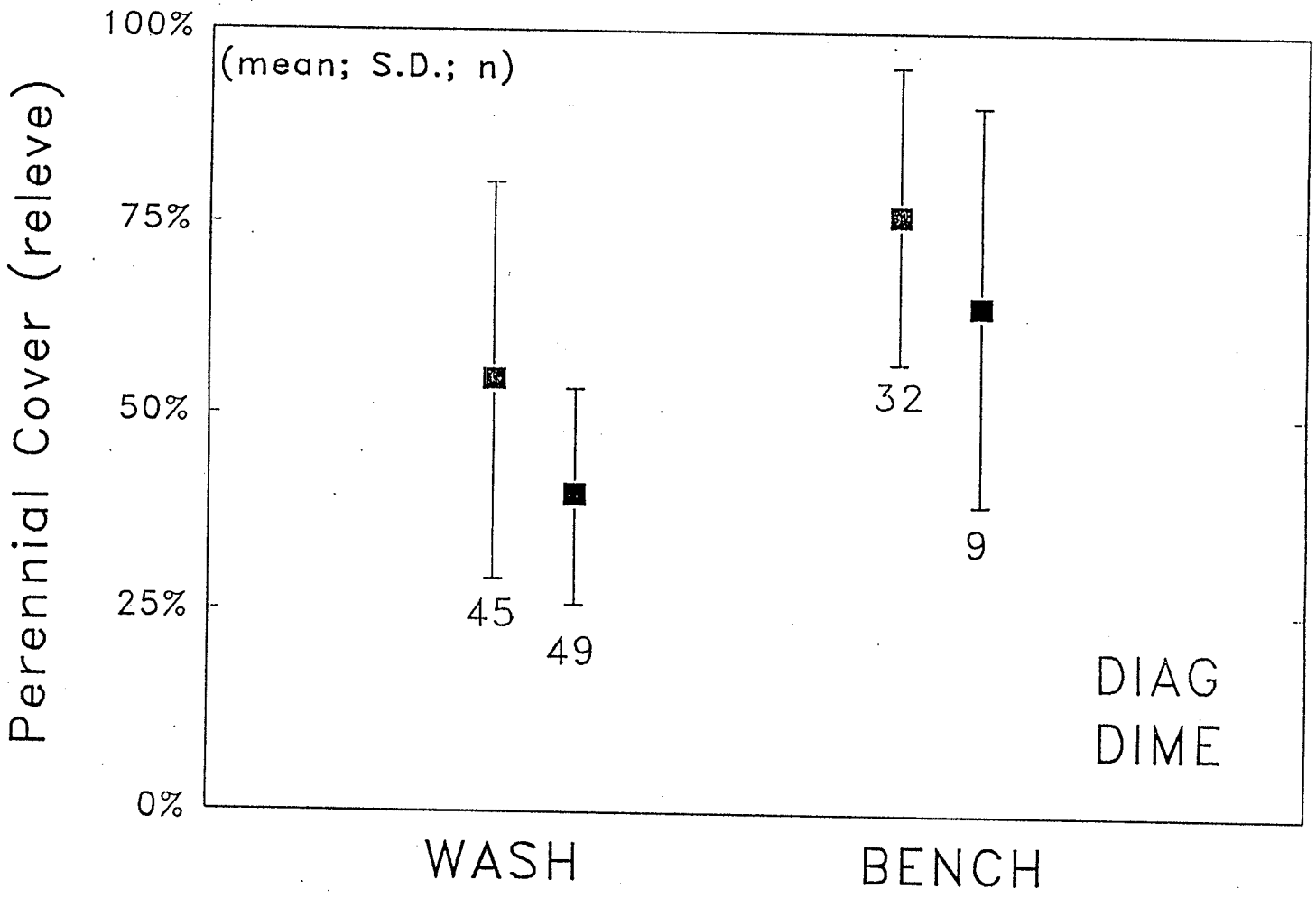
$x^2 = 27.586$ $P < .00001$

DIAG

	WASH	BENCH
OBS	45	32
EXP	39	39

$x^2 = 2.195$ $P = .1385$

Figure 13.


100%
75%
50%
25%
0%
Perennial Cover (releve)
(mean; S.D.; n)
45
49
32
9
DIAG
DIME
WASH
BENCH

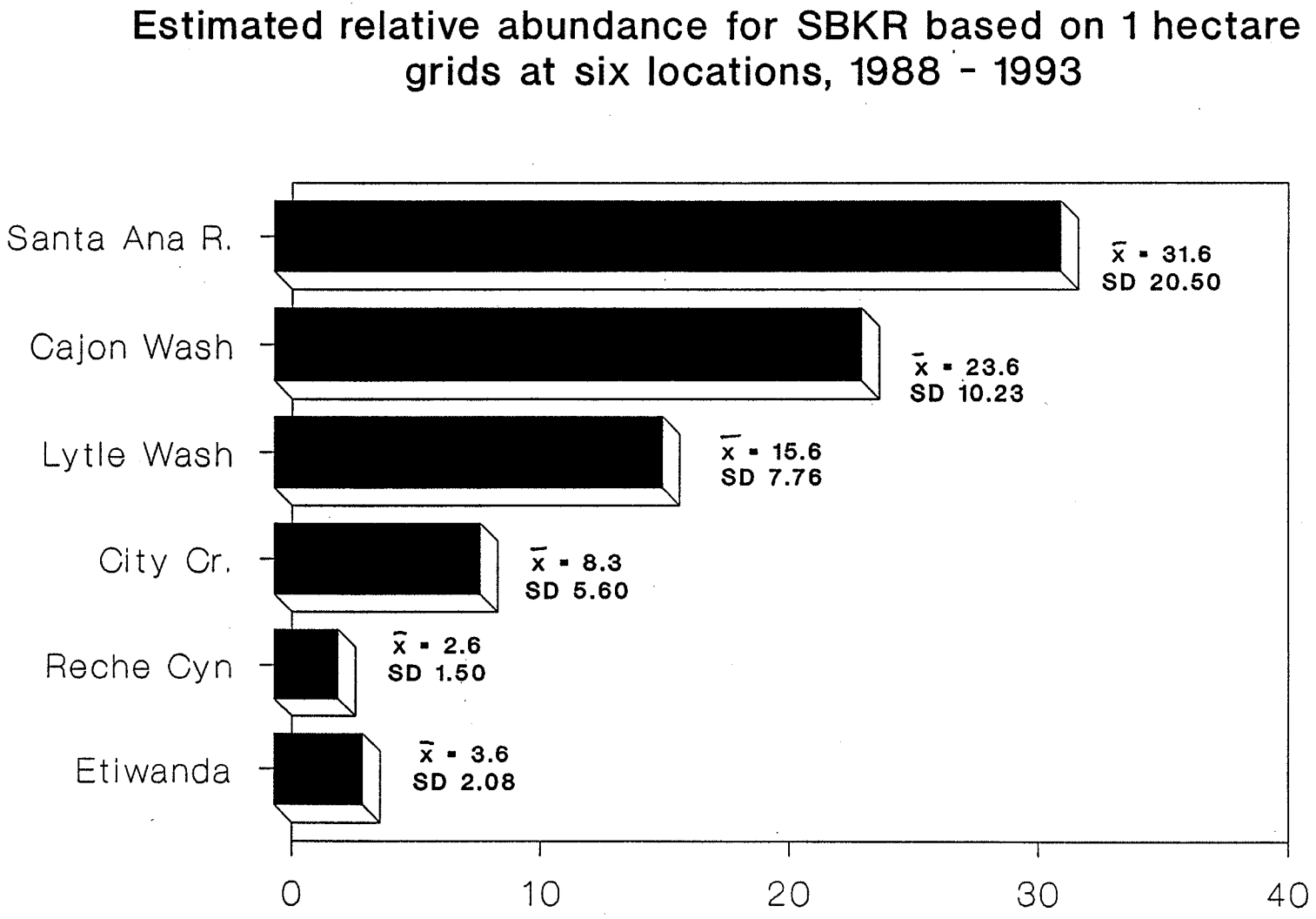
natives have precluded SBKR from these habitats (i.e. portions of sections 7 and 11 within the Santa Ana Wash).

Relative Abundance for SBKR at Selected Sites

Several factors are responsible for differences in the relative abundances of SBKR among sites. Differences in habitat quality and structure are the fundamental reasons for these differences. Currently, the SBKR preferred habitat is the early successional phases of the AFSS. Although all localities in which SBKR presently occupies have these early phases represented, the overall habitat quality at these occupied sites varies widely. This variability among sites is due to either the lack of fluvial actions, the decadence of the AFSS, or the presence of non-native annual plants.

Relative abundances for SBKR were evaluated using one hectare grids over a 5 year period at six locations in San Bernardino Valley (Figure 14). The sampling was an unequal effort for these sites based on the extent of AFSS. The Santa Ana River site included portions of section 7, 11, 13, and 14. The mean relative abundances for SBKR at this location was $x = 31.6$, sd 20.50. The variability in relative abundances at this location appears to be due, in part, to the amount of pioneer and intermediate phase AFSS. The one hectare grids were usually placed in early successional area although due to specific fluvial patterns mature AFSS commonly constitutes some portion of the each grid. Cajon Wash was sampled over the same period with the mean relative abundance of $x = 23.6$, sd 10.23. The Cajon Wash sites included areas down stream of Institution Road and downstream of Devore Road. The randomly placed grids were

Figure 14.


Estimated relative abundance for SBKR based on 1 hectare grids at six locations, 1988 - 1993
Santa Ana R.
x̄ = 31.6
SD 20.50
Cajon Wash
x̄ = 23.6
SD 10.23
Lytle Wash
x̄ = 15.6
SD 7.76
City Cr.
x̄ = 8.3
SD 5.60
Reche Cyn
x̄ = 2.6
SD 1.50
Etiwanda
x̄ = 3.6
SD 2.08
0
10
20
30
40

usually in early successional AFSS with large tracts of pioneer phase. Included in the Cajon grids were fairly extensive areas of scoured wash channels. The Lytle Wash was sampled between the Interstate 15 and the confluence of Cajon and Lytle Creeks. The mean relative abundances of SBKR for this area was x = 15.6, sd 7.76. Lytle Wash is very similar to that of Cajon Wash relative to the fluvial patterns and structure of the AFSS. In both the Cajon and Lytle locations AFSS successional patterns are similar with pioneer phase being the major element of the AFSS habitats. The City Creek one hectare grid was located in the flood control channel. The mean relative abundance for SBKR at this was x = 8.3, sd 1.50. The City Creek site contains principally intermediate phases of AFSS with a considerable amount of flood control activity in the channel.

The Reche Canyon site is along the Reche Canyon wash. This location has very little AFSS with the mean relative abundance for SBKR being x = 2.6, sd 1.50. Most of the remaining wash habitat in Reche Canyon is disturb with a scoured wash course and isolated patches of AFSS. The last location sampled was East Etiwanda Creek. This location has marginal AFSS with high levels of disturbance. The mean relative abundance for SBKR at this site was x = 3.6, sd 2.08. The area trapped was at the southern end of the existing percolation basins. This location is subjected to moderate to high levels of flood control activities.

Generally the mean values for the relative abundances of SBKR at these six sites reflect the amount of habitat, its quality, and successional patterns. These noted characteristics all determine the relative abundance of SBKR for each location.

Estimates of Historic SBKR Occupied Habitat

As previously indicated AFSS habitats have dramatically declined over the past 50 years in the coastal valleys of Southern California. To determine the amount of decline relative to the historic and current range of the SBKR aerial photographs of the southern San Bernardino County and northwest and north central Riverside County were examined. This photo examination is considered an estimate of the AFSS present and the approximate acreage of preferred/occupied SBKR habitat circa 1930. The historic map quality varied with respect to map condition, flight elevation, and map scale.

The historic distribution of AFSS was broad ranging in the San Bernardino Valley area and northwestern Riverside County. Particularly in the last eighty years, rapid and extensive urbanization has significantly altered the Southern California environment. Streams and rivers have been extensively modified for the purpose of flood control and water supply. A prime example of this change is the total drainage area of streams and rivers in Southern California which exceeds 32,000 square kilometers, of which 53 percent is controlled by dams and reservoirs (Brownlie and Taylor 1981).

In the San Bernardino Valley the Santa Ana River and its tributaries included a broad uncontrolled floodplain historically. The Santa Ana River, Mill Creek, Plunge Creek, and City Creek all emerged from canyons and foothills of the San Bernardino Mountains at Mentone, forming a floodplain alluvial wash 10 miles long and on an average of 3 miles wide (Ingels, 1929).

The Lytle and Cajon Creek drainages from San Gabriel and San Bernardino Mountains flow into the Santa Ana River. Historically, each of these creeks spread many miles across a broad gravelly alluvial floodplains (Smith, 1980).

The examination of historic aerial photographs for the Santa Ana River floodplain and the Lytle and Cajon Creek floodplains reflect the presence of three physiographic zones of different ages that support distinct types of vegetation: a wash, a terrace above the wash, and a higher alluvial terrace (Smith, 1980). In addition, away from the major floodplain influences of these mentioned fluvial systems, other extensive portions of the San Bernardino Valley contained distinct physiographic zones such as washes, and alluvial terraces. The locations which had extensive alluvial areas included the western and southern portion of San Bernardino Valley.

Historic photographs for the northwestern portion of Riverside County convey a different situation. Generally, alluvial washes and terraces of AFSS in this area were associated with the Santa Ana River and minor drainages originating from the Box Spring Mountains or Jurupa Mountains. These unchannelized washes provided narrow but extensive areas of pioneer phases of AFSS with islands or remnants of a higher alluvial terrace, most of which have been destroyed. Within the north-central portion of Riverside County historically the primary area for AFSS was along the San Jacinto River floodplain. Although this river system had been channelized as early as 1917 (Willet, 1917), various flooding events breached the San Jacinto River levee.

The nature of the San Jacinto River channel provided

extensive areas of AFSS along various portions of its floodplain in the San Jacinto Valley and in Valle Vista areas.

Estimates based on aerial photograph (circa 1930) evaluation indicates that for the eastern portion of San Bernardino Valley, which includes the Santa Ana River floodplain, approximately 9,500 acres of presumed suitable habitat existed for SBKR (Figure 15). The northern portion of the SBV which includes the Cajon and Lytle Creek floodplains contained approximately 8,000 acres of suitable habitat (Figure 15). The western portion of SBV which includes Etiwanda alluvial fan and various creeks and washes which flow out of the San Gabriel Mountains across the fan contained approximately 4,000 acres of presumed suitable habitat (Figure 15). The southern portion of SBV which includes the base of the Jurupa Mountains and vicinity comprised approximately 1,500 acres of suitable SBKR habitat.

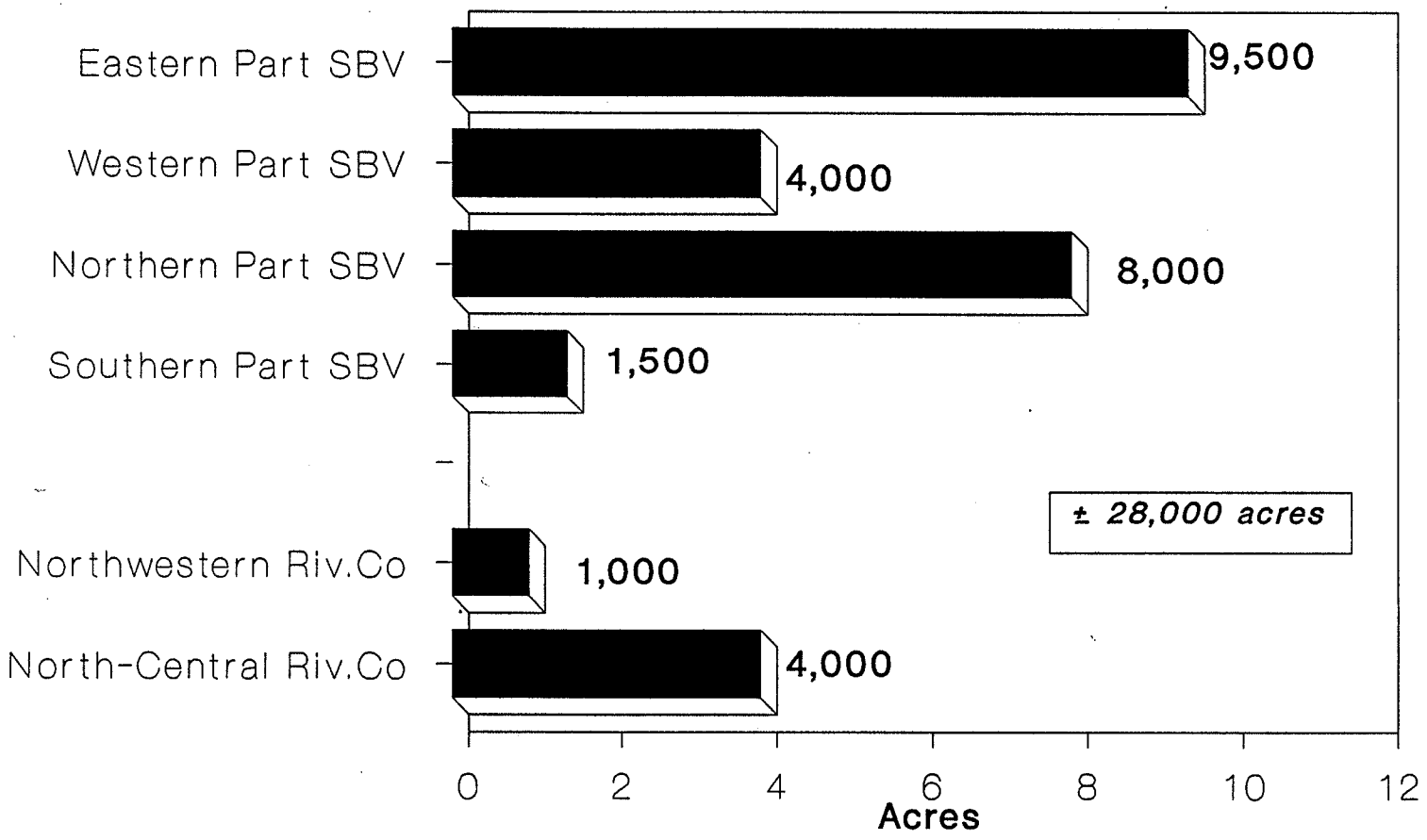
Historic estimated acreages for occupied SBKR habitat in the northwestern portion of Riverside County includes areas south of Jurupa Mountains, and along the floodplain of Santa Ana River. There was approximately 1,000 acres of occupied SBKR habitat in this area (Figure 15). The north-central portion of Riverside County includes the San Jacinto River south to Menifee, which contained approximate 4,000 acres of occupied SBKR habitat.

These historic acreages for SBKR occupied habitats are obviously estimates which were delineated from aerial photograph and could have some error associated with them. However, based on the distinct types of physical characteristic and related types of vegetation in these fluvial systems which can be detected on aerial photography these estimates are the best

Figure 15.

#19305

Estimated acreage of historic suitable habitat for SBKR



SBV = San Bernardino Valley
Riv Co. = Riverside County

interpretation to date.

Acreage Estimates for Current SBKR Occupied Habitat

Current acreage estimates have been collected through trapping over the SBKR historic range and examination of 1993 aerial photographs of both San Bernardino and Riverside Counties.

The significant loss of AFSS over the historic range of the SBKR has reduced occupied SBKR habitat by 86%. Of the 14% (2032 acres) of occupied SBKR habitat remaining approximately 81% (1650 acres) exist along three floodplains in San Bernardino Valley; Lytle Wash (300 acres), Cajon Wash (425 acres), and Santa Ana Wash (925 acres) (Table 2). Outside of these three floodplains in the San Bernardino Valley only 0.01% (32 acres) contain SBKR occupied habitat (Figure 16).

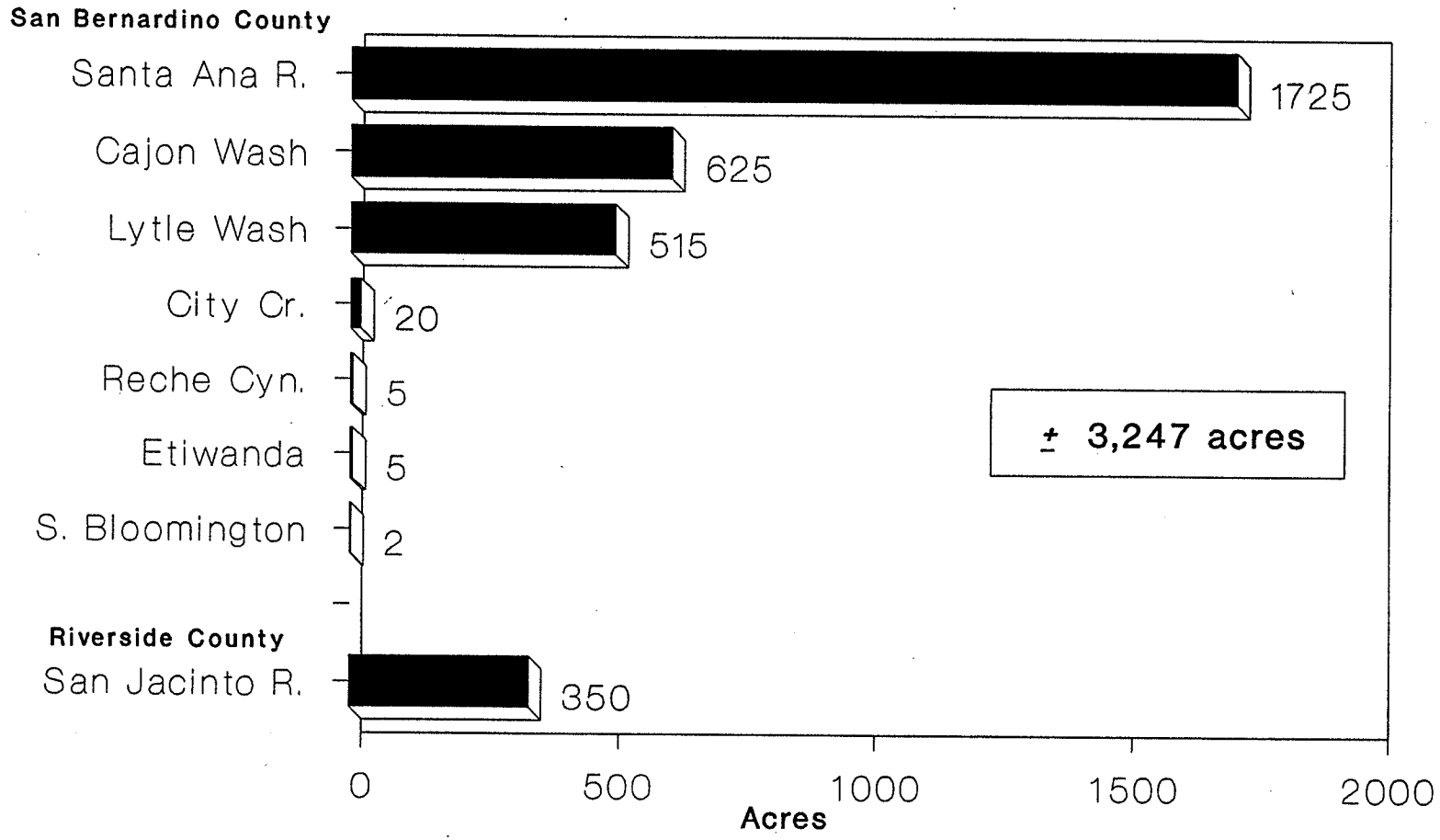
In Riverside County of the approximate 5000 acres of historically occupied SBKR habitat only 7% (350 acres) remain (Figure 16). This 350 acres are along the San Jacinto River near Hemet.

Relative Abundance Index for Occupied SBKR Habitat

To establish a relative abundance index for SBKR and the relative quality of occupied habitat a rating was developed based on trapping success between 1988 and 1996. This relative abundance rating was developed through mark and re-capture along the Santa Ana River, Cajon Creek, and Lytle Creek in various AFSS habitat conditions (vegetation cover, terrace age, etc.). The range of abundances are closely related to AFSS succession stages and the extent of a particular successional type. Trapping to determine these relative abundances were conducted over all seasons to account for seasonal variability.

Figure 16.

Approximate acreage of known occupied SBKR habitat, 1996



The range of abundances are for numbers of SBKR per one hectare; low abundance are 1-5 animals, moderate abundances are 5-15 animals, and high abundances are 20-30 animals per hectare (Figure 17). These abundances are generally correlated with the quality of habitat and to some degree the amount of habitat at a particular site (Figure 18). The locations with low ratings are usually in areas with dense cover of non-native annual plants or decadent mature AFSS stands which usually have bisecting narrow channels of young aged AFSS. The moderate abundances are usually associated with intermediate phases of AFSS. While the high relative abundances are for locations with pioneer to intermediate phases of AFSS in active fluvial zones (Figure 19).

Reproductive Aspects of SBKR

The reproductive biology of the SBKR is comparable to the nominate merriam's kangaroo rat (Reynolds 1960). To determine reproductive status (scrotal/lactating) for SBKR live trapping was conducted over a 2 year period (1988-1990) in Santa Ana Wash and Cajon Wash. Male SBKR captured in the scrotal state ranged from January through August with the greatest number of males with scrotal condition occurring during July (Figure 20). Females were captured either pregnant or lactating in trapped populations between January through late November. The peak number of females in either pregnant or lactating conditions was during late June (Figure 20).

The frequency of juvenile SBKR in a given population was determined through multi-year and season trapping within the Santa Ana Wash over a 4 year period (1989-1992). The peak

Figure 17.

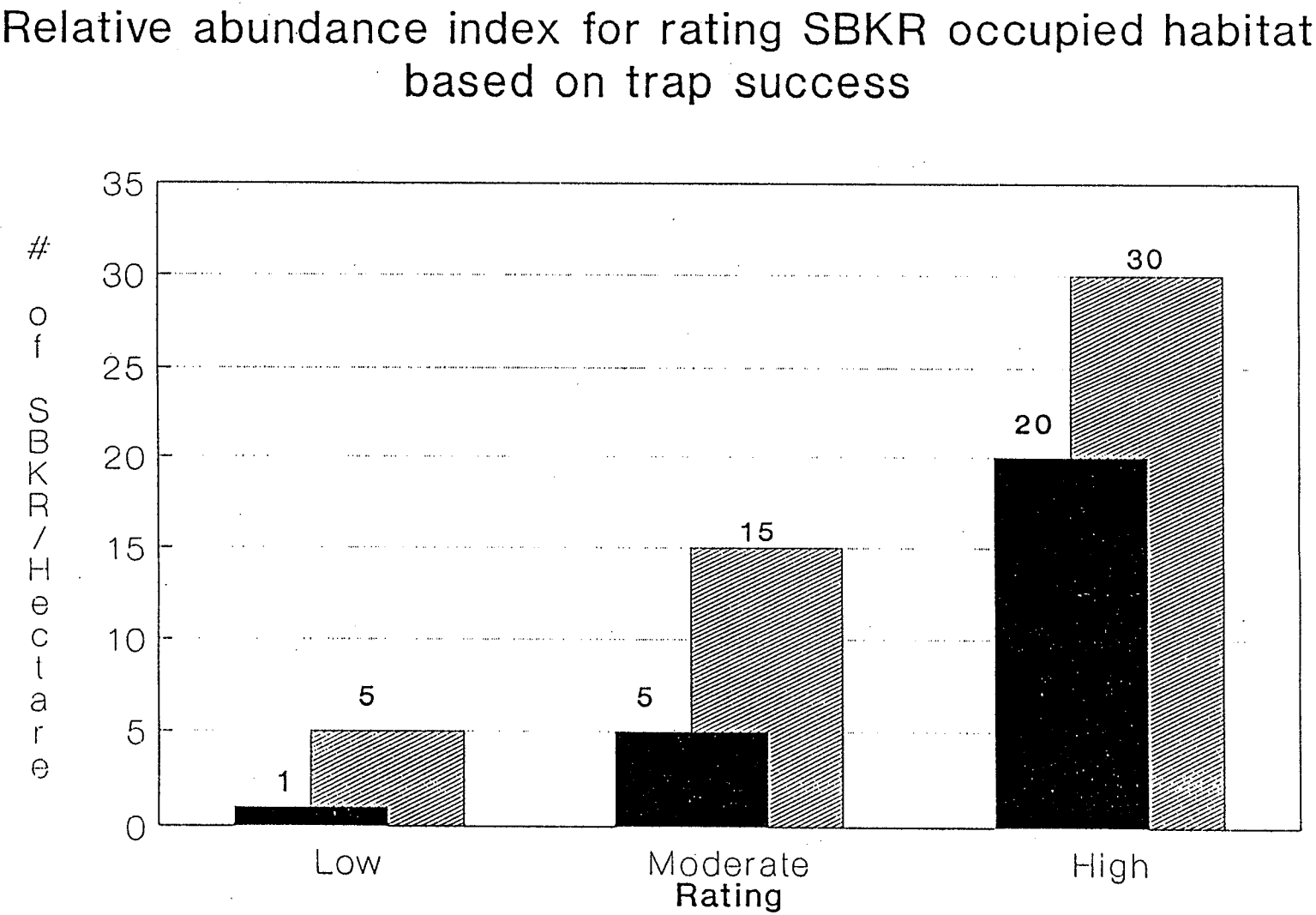

Relative abundance index for rating SBKR occupied habitat based on trap success
# of SBKR/Hectare
35
30
25
20
15
10
5
0
1
5
5
15
20
30
Low
Moderate
High
Rating

Figure 18.

Idealized diagram showing SBKR occupied habitat within a fluvial system, braided channels and pioneer phase are usually the centers of the subspecies distribution.

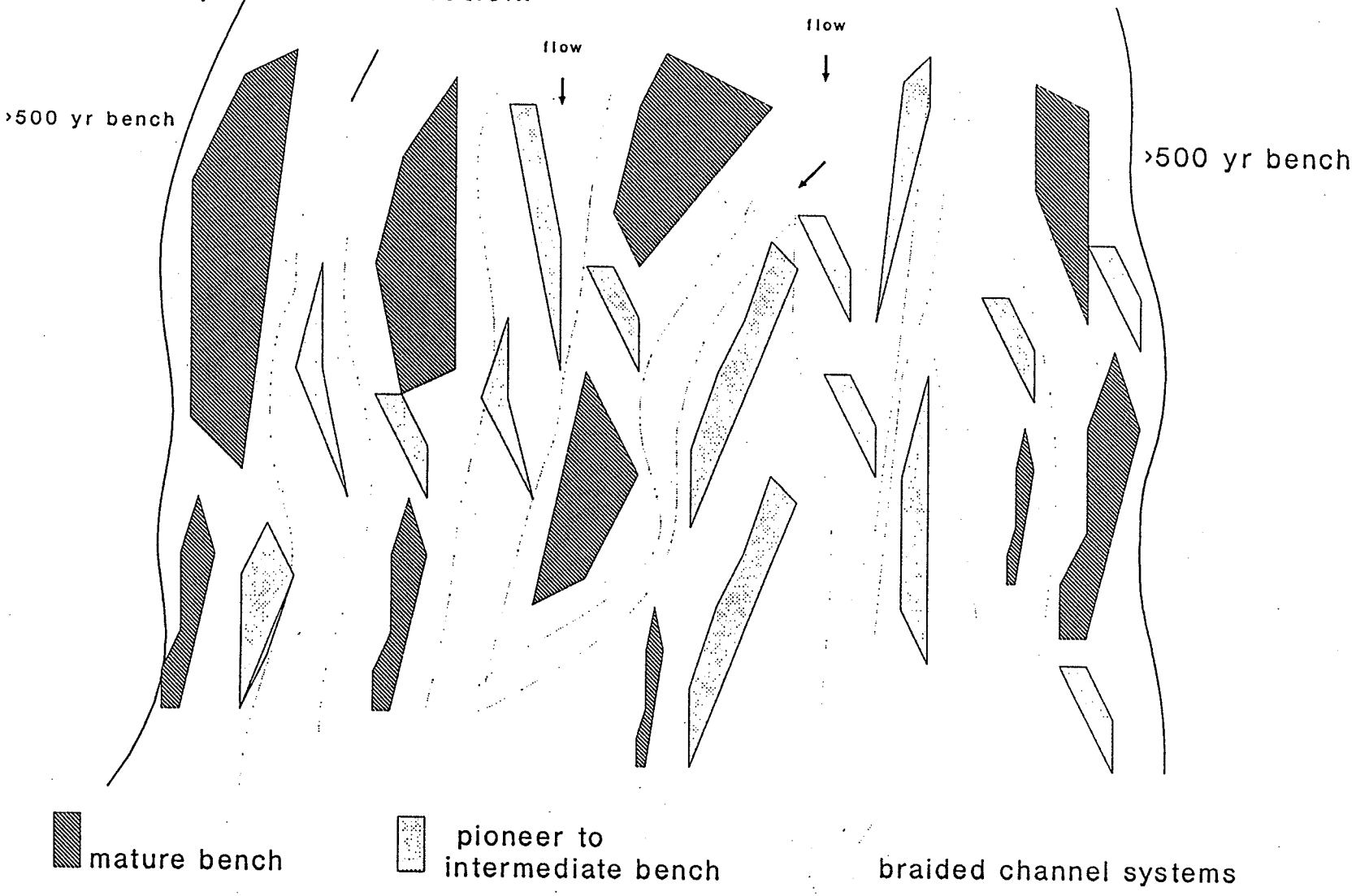


Figure 19.

Idealized cross-section showing SBKR distribution within a fluvial system, SBKR normally reaches its maximum abundance within the pioneer to intermediate phase of a fluvial system.

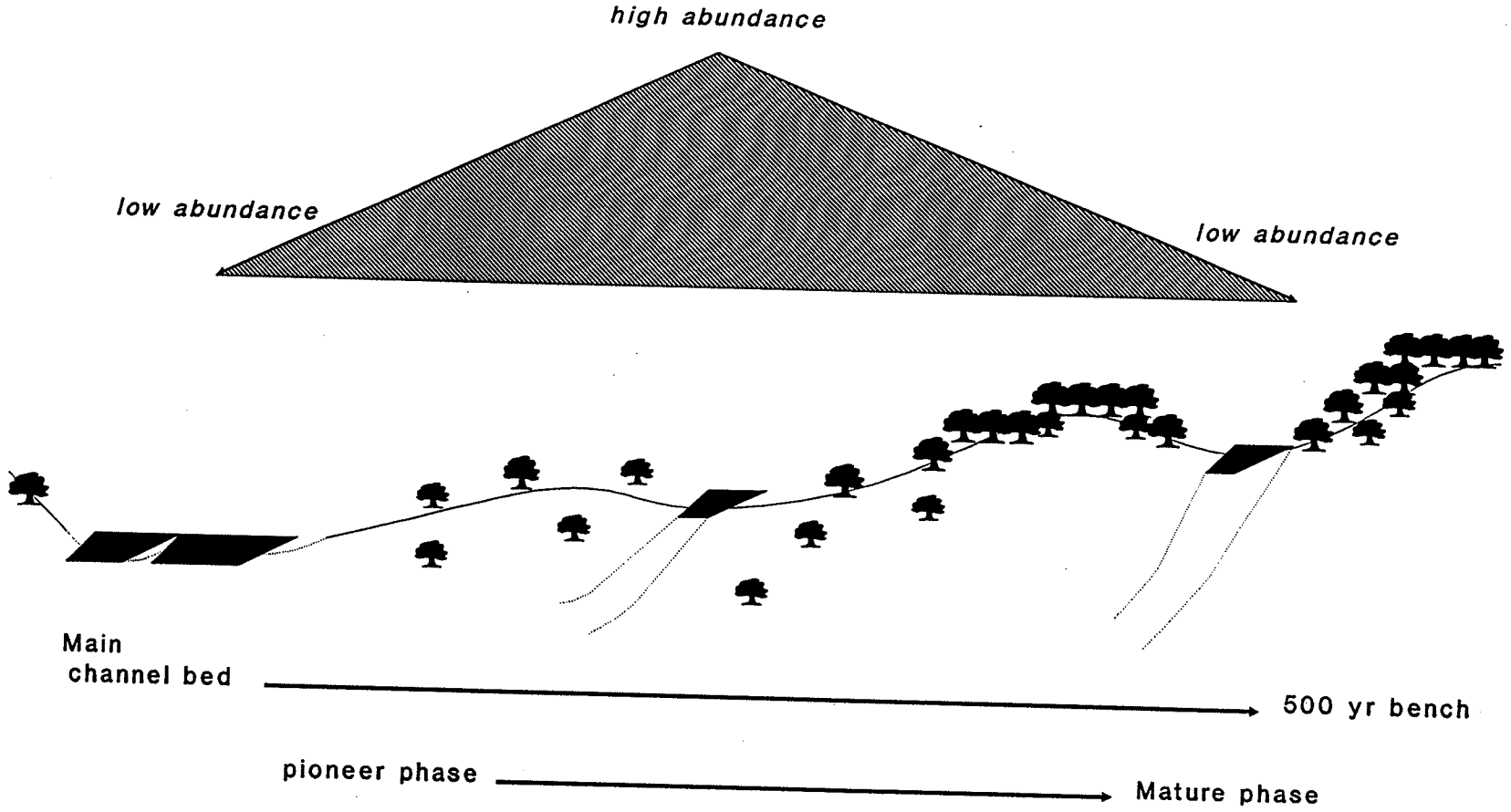
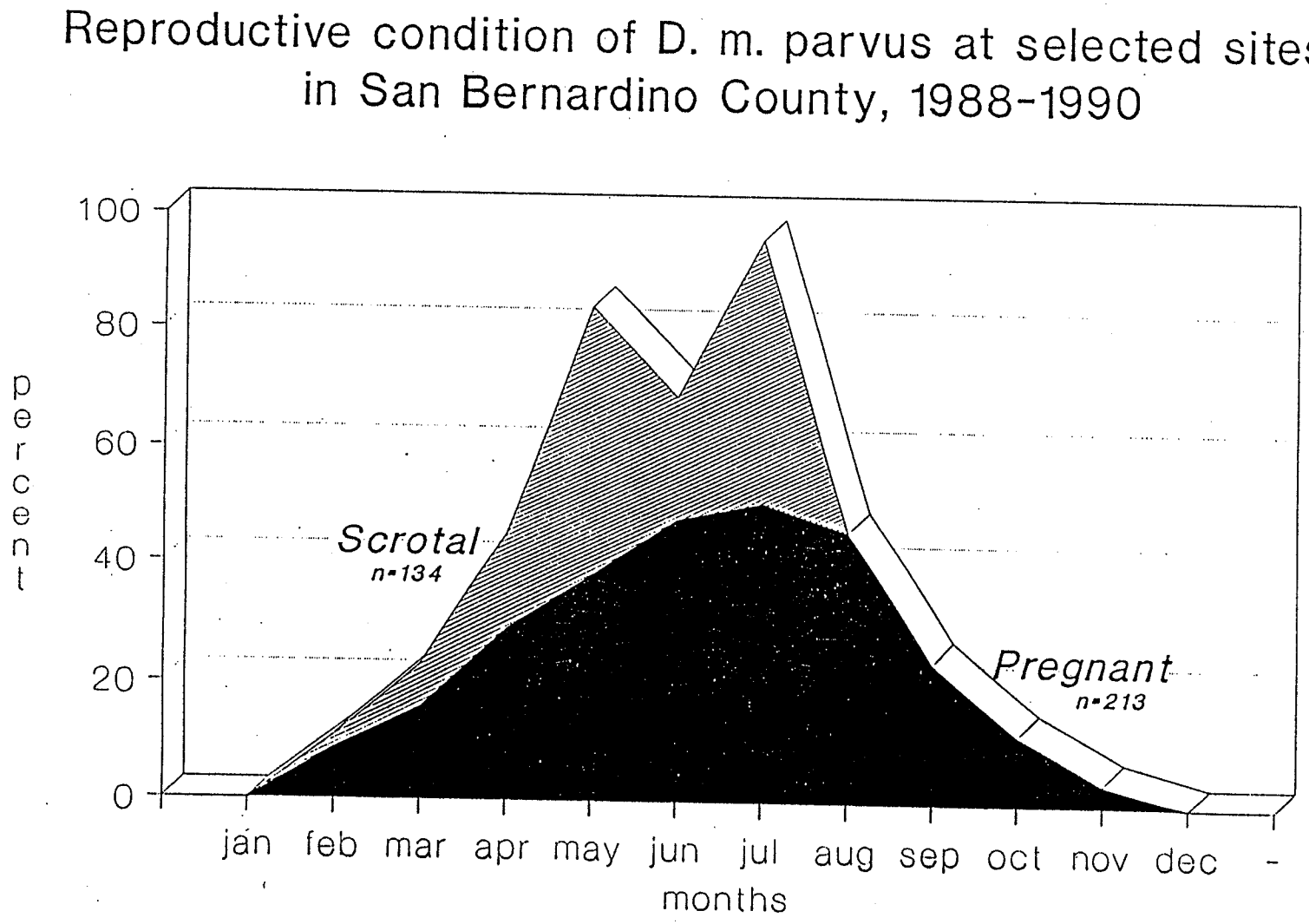


Figure 20.


Reproductive condition of D. m. parvus at selected sites in San Bernardino County, 1988-1990
100
80
60
40
20
0
percent
Scrotal
n=134
Pregnant
n=213
jan feb mar apr may jun jul aug sep oct nov dec
months

occurrence of juvenile SBKR in established one hectare grids was during August (Figure 21). These projections for recruitment are for high quality AFSS habitats which primarily contained pioneer and intermediate phases. These high quality habitats usually contain a high relative abundances for SBKR.

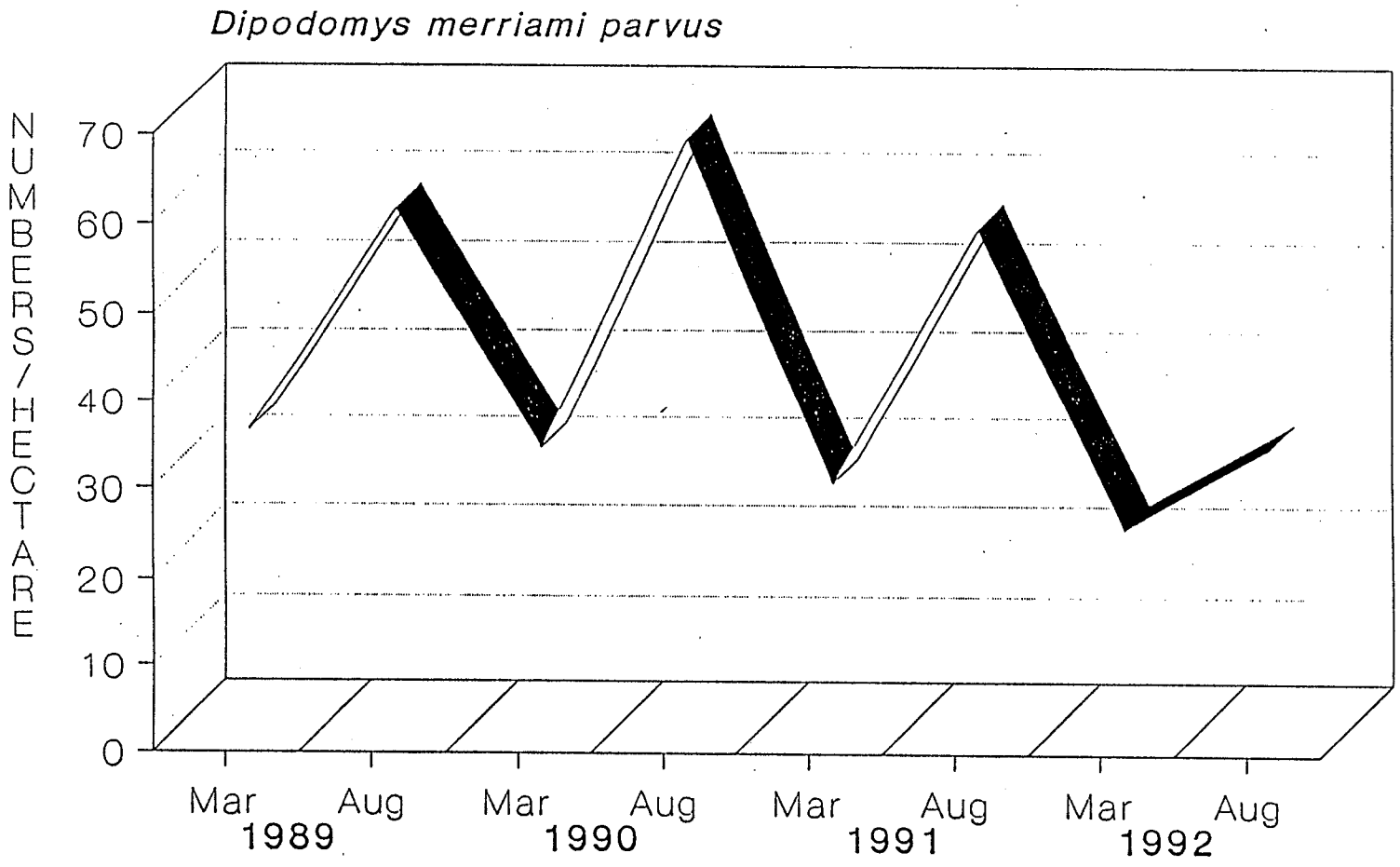
Overall Summary and Status of SBKR

The SBKR today is primarily restricted to a dynamic ecosystem where it reaches its maximum abundances in active pristine fluvial systems. This subspecies is exploiting a limited breadth of physical conditions within the alluvial floodplain environment. These active fluvial systems were once widespread and unaffected historically. Since the 1930's floodplain modifications through flood control activities, sand and gravel mining, agricultural land conversion, road construction, and bridge construction has reduce these active fluvial systems to a fraction of what was once extensive in the region.

Through the loss and fragmentation of San Bernardino kangaroo habitat a precarious situation for this subspecies has been created. The loss of suitable habitat and the alteration of fluvial systems has reduced SBKR occupied habitat to approximately 2,032 acres of alluvial fan sage scrub habitat. This remaining 3-5% of the subspecies original occupied range is being reduced and fragmented which further threatens the long-term persistence of this subspecies. The current core populations of this subspecies are now isolated from each other. Moreover, these populations are being impacted by a variety of

Figure 21.

Four years of trapping results for the Santa Ana River



activities. The Santa Ana River wash with sand and gravel mining, water percolation activities, ongoing development of infrastructure and the most significant impact being the Army Corps of Engineers Seven Oaks Dam project has invoked a perilous situation for this vital subpopulation area. This perilous situation is obviously clear with the creation of Seven Oaks Dam which will restrict and diminish downstream fluvial actions which are needed to restore and maintain AFSS along the Santa Ana River floodplain. The interruption of flooding events large or small along the Santa Ana River floodplain will have significant adverse effects on the viability of this floodplains extant SBKR subpopulations.

Another critical area for the subspecies distribution is the Cajon Creek and Lytle Creek floodplains which contain less occupied acreage than Santa Ana River wash but have an equally significant subpopulation of SBKR. The Cajon and Lytle washes have numerous activities which threaten the integrity of the AFSS and thereby SBKR populations. Though no major dam projects are proposed for this watershed, the various other floodplain activities have created extensive fragmentation, destruction, and degradation of SBKR occupied habitat. Within these two washes sand and gravel mining and infrastructure are the greatest threats to occupied SBKR habitat. The modifications to these floodplains can be measured in the reduction in the width, and change in the flooding activity of the fluvial system. These alterations to the floodplains have produced a reduction in the early successional phases of AFSS. Without fluvial actions within a AFSS floodplain maturity of the AFSS is anticipated.

This phenomena of maturity and ultimate decadence of AFSS throughout the range of SBKR is one of the foremost problems confronting this subspecies. There are many areas which contain sizable tracts of AFSS specifically in San Bernardino County, however frequently these intact floodplains are either devoid of or have notably reduced flooding events. A particular situation considered "shadowing" occurs downstream of flood control dikes, basins, roads, and other diversions which isolate AFSS from upstream fluvial activities. Over time these once occupied SBKR AFSS habitats become mature stands of AFSS which makes them inferior or totally unsuitable for SBKR occupation (Figure 22).

The extant SBKR populations are now very limited within the San Bernardino and Riverside Counties. The San Bernardino kangaroo rat's current status is very precarious. San Bernardino kangaroo rat warrants immediate consideration by USFWS for the listing of this subspecies as endangered under the ESA.

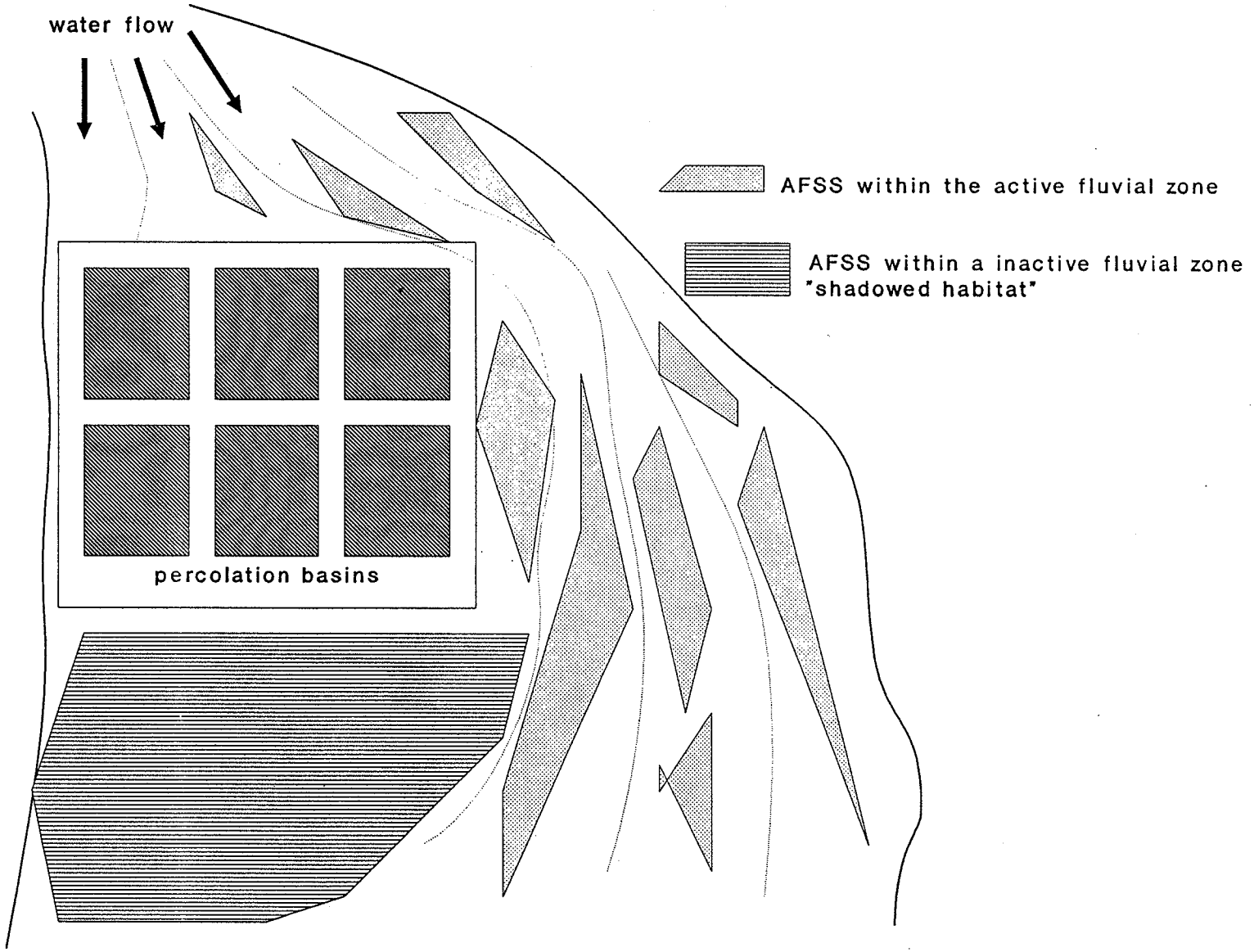
CONCLUSIONS AND RECOMMENDATION

Several recommended actions and suggestions for conservation and additional research on San Bernardino kangaroo can be made based on information provided in this report. Future research should seek to build on baseline information of SBKR. The following recommendations are in order of priority:

1. Preparation and implementation of management plans for SBKR at Santa Ana River Wash floodplain, Cajon Creek Wash floodplain, Lytle Creek Wash floodplain, and San Jacinto River floodplain near Hemet. These four areas hold the most significant extant populations of SBKR. A conservation strategy for these existing

Figure 22.

Idealized diagram indicating the shadowing effects within a floodplain which creates maturity of AFSS habitats.



floodplains should be developed which details prudent measures for the persistence of SBKR populations for the long term on both public and private lands.

2. A detailed study of this subspecies should include specific measured habitat affinities, viable population estimates for each subpopulation, and general biology attributes for SBKR. In addition, a more refined trapping protocol study should be conducted for SBKR which would aid in the long-term monitoring and conservation of the subspecies.

3. Determine the immediate and long-term effects of primary and secondary impacts to floodplain systems which contain SBKR populations. This would include how infrastructure (i.e. roads, dike's, bridges, and percolation basins, etc.) can obstruct fluvial actions within a floodplain environment and diminish the quality of habitat suitable for SBKR.

4. Although no proven method exist for restoration of AFSS habitat within active fluvial zones, restoration measures should be explored which would be one aspect in the recovery of SBKR preferred habitat.

5. Suppression/eradication of invasive non-native plants in fluvial systems throughout SBKR current distribution.

REFERENCES.

Brownlie, W.R. and B.D. Taylor. 1981. Sediment management for southern California mountains, coastal plains, and shore line. Calif. Inst. Technol. EQL Rep. 17-C. 314pp.

Hall, E.R. 1981. The mammals of North America. Ronald Press, New York, 2 Volumes.

Ingles, L.G. 1929. The seasonal and associational distribution of the fauna of the upper Santa Ana River Wash. J. Ent. Zool. 21:1-96.

Jolly, G.M. 1965. Explicit estimates from capture-recapture data with both death and immigration-stochastic model. Biometrika 52:225-247.

Lidicker, W.Z., Jr. 1960. An analysis of intraspecific variation in the kangaroo rat Dipodomys merriami. Univ. California Publ. Zool., 67:125-218.

McKernan, R.L. 1993. San Bernardino Kangaroo Rat (*Dipodomys merriami parvus*), in BIOLOGY AND MANAGEMENT OF RODENTS IN SOUTHERN CALIFORNIA, 111 pp.

Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley and Sons. N.Y. 547 pp.

O'Farrell, Michael J., and Curt Uptain. 1989. Assessment of Population and Habitat Status of the Stephen's Kangaroo Rat (*Dipodomys stephensi*). California Department of Fish and Game, Wildlife Management Division, Nongame Bird and Mammal Section, Sacramento.

Smith, R.L. 1980. Alluvial scrub vegetation of the San Gabriel River floodplain, California. Madrono 27 (3): 126-138.

Westman, W.E. 1981. Diversity relationships and succession in California coastal sage scrub. Ecology. 62:170-184.

Willet, G. 1917. Notes on the birds of San Jacinto Valley. The Condor, Vol XIX, No.6

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