

REPTILES AND AMPHIBIANS OF VANDENBERG AIR FORCE BASE

A FOCUS ON SENSITIVE AQUATIC SPECIES

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SANTA BARBARA COUNTY,
CALIFORNIA
1995

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Summary

Few herpetological studies have been performed on Vandenberg Air Force Base, California (VAFB). Very little was known about the distribution and status of reptiles and amphibians since many of these species have a short period of seasonal activity, are nocturnal, or occur in areas that are difficult to access, and thus were not easily detected in the course of general biological surveys. The aim of this study was to determine the distributions, habitat associations, and relative abundances of sensitive aquatic reptile and amphibian species on VAFB. A secondary goal was to document the distributions of all amphibian and reptile species on VAFB by collection of voucher specimens (housed at the Museum of Systematics and Ecology, University of California, Santa Barbara), and preparation of maps detailing collection and sighting information.

The western spadefoot toad (*Spea hammondi*), was documented from VAFB, while the California tiger salamander (*Ambystoma californiense*) was not. Several authors had listed these species as "expected to occur on VAFB" but no evidence was found previously. Western spadefoot toads preferred sites with sandy substrates and seasonal rain pools which were relatively large and deep. The red-legged frog (*Rana aurora*), and western pond turtle (*Clemmys marmorata*), were found distributed throughout pond, lake, and stream sites. Both species were associated with deep water and the presence of aquatic vegetation. Success of red-legged frog reproduction appeared to be positively correlated with aquatic vegetation. Pre-adult stages of red-legged frogs were impacted by unseasonably-late storm events, and were negatively correlated with the presence of introduced fish species and bullfrogs. The

two-striped garter snake (*Thamnophis hammondi*) was found in riverine wetland systems, especially those with abundant fish or tadpole prey. Sensitive terrestrial species, the coast horned lizard (*Phrynosoma coronatum*) and California legless lizard (*Anniella pulchra*) were patchily distributed. A total of 8 amphibian species and 16 reptile species were found to occur at VAFB.

Factors which may affect western spadefoot toads include alteration of habitat during land development and iceplant (*Carpobrotus* sp.) invasion. Some individuals may be lost due to crushing by vehicles during movements between refuge and breeding sites. Potential threats to red-legged frogs and western pond turtles include the expansion of predatory fish and bullfrog populations. Loss of deep pools due to scouring floods, or filling by eroded material (which is exacerbated by livestock grazing and agricultural practices) decreases stream habitat suitability. Presence of introduced beaver (*Castor canadensis*) populations may benefit these pond-dwelling amphibians and reptiles. Feral pigs (*Sus scrofa*) may negatively affect red-legged frogs and western pond turtles by altering vegetative characteristics and through predation on adults and eggs. Groundwater overdraft in the San Antonio Valley threatens red-legged frogs, western pond turtles, and two-striped garter snakes in this area. Amphibians and reptiles at Jalama lagoon were disturbed or collected frequently by visitors to Jalama Beach County Park. Individuals are lost to crushing by vehicles during overland movements throughout VAFB. Water quality issues in Shuman Canyon Creek, Santa Ynez River and San Antonio Creek should be addressed by further study.

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1.0 INTRODUCTION

1.1 Project Background

1.1.1 Study Area

Vandenberg Air Force Base (VAFB or Base) in northern Santa Barbara County, California (Figure 1), is 98,400 acres of upfaulted and folded ridges and mesas with a complex of dune systems and downfaulted and incised canyons. This area is biologically unique because it is considered to be a transition zone between northern and southern California (Munz and Keck 1959), with many species reaching their northern or southern limits on the Base (Coulombe and Cooper 1976). There is a considerable amount of freshwater habitat on VAFB, including 52.7 miles of semi-permanent creeks, 283,800 m² of lakes and ponds, in addition to lagoons and marshes (Coulombe and Cooper 1976, Coulombe and Mahrtdt 1976).

Midway through the Base, the Santa Ynez River meets the Pacific Ocean, with a 58 acre lagoon (Coulombe and Cooper 1976). Because of dams in the river's middle reaches, the lower Santa Ynez is presently an intermittent river with its summer flow derived mainly from agricultural runoff and sewage effluent (Coulombe and Cooper 1976). The Santa Ynez River is the boundary between "North Base" and "South Base". Shuman Creek and San Antonio Creek are the two largest stream systems on North Base. Most of the 4.4 miles that Shuman Creek runs through VAFB are dry in summer months, with the exception of a small lagoon and some deep pools below the confluence of Casmalia Creek. Barka Slough, in San Antonio Valley near the eastern Base boundary, is a palustrine emergent and forested wetland dominated by willow woodland and emergent marsh (Dial 1980). At one time Barka Slough had one of the largest emergent wetlands in the

county (Smith et al. 1976), but it has experienced considerable reduction in wetland acreage due to excessive ground-water use for agricultural irrigation (Dial 1980, Hutchinson 1980, Mallory 1980, Dames and Moore 1985). The San Antonio Valley has the largest riparian woodland on VAFB.

Cañada Honda, Lompoc Canyon Creek, and a few small drainages in the Sudden Ranch area are the only riverine wetland systems on South Base. Almost all of the watershed of Cañada Honda lies within VAFB. This well-shaded stream has a narrow, steep canyon which is prone to erosion (Coulombe and Cooper 1976). Lompoc Canyon Creek has little flow, and is channelized below its confluence with San Miguelito Creek. Of the generally small (0.5 to 3 m wide) streams of Sudden Ranch, the largest is Cañada del Jolloru. Sudden Ranch streams have been heavily damaged by cattle (Coulombe and Cooper 1976, personal observation) and have steep, eroded banks.

Other freshwater resources on VAFB include numerous vernal pools, dune swale ponds, naturalized created ponds, waterfowl ponds, lakes, cattle ponds, and settling ponds. Many of these habitats are rare in Santa Barbara County (Henningson et al. 1984b), and are exceptionally productive sites for amphibians. The largest impoundments on VAFB are Punchbowl Lake (surface area 55,000 m²), Mod III Lake (39,000 m²), and Pine Canyon Lakes (46,000, 42,000, and 23,000 m²) all of which are artificial (Coulombe and Cooper 1976). The latter occurs in Lake Canyon according to U. S. Geological Survey Topographical Maps, instead of the nearby Pine Canyon. These lakes are or have been stocked for sport fishing by Base personnel (Coulombe and Cooper 1976, Coulombe and Mahrtdt 1976). San Antonio Terrace is the site for numerous dune swale ponds described by Human (1990). Vernal pools occur mainly on North Base, with the greatest number on Burton Mesa. The

condition of these habitats varies with rainfall. The present study took place in an exceptionally wet year, with at least 25.7 inches of rain from September 1994 through April 1995 (data are missing for November 1994) (VAFB Weather Squadron, personal communication).

1.1.2 Previous Herpetological Work

The herpetofaunal resources of VAFB have been poorly documented. A few accounts list species encountered during general biological surveys, but searches specifically for amphibians and reptiles using proper techniques have not been undertaken. The most comprehensive work was an ecological assessment of the Base which used pit and Sherman traps to determine indices of vertebrate relative abundance (Coulombe and Cooper 1976, Coulombe and Mahrtdt 1976). Traps used were not suitable for sampling red-legged frogs (*Rana aurora*) or western pond turtles (*Clemmys marmorata*), and appropriate visual surveys were not performed. Trap data, observational data, and expected species occurrences derived from range maps were used to compile a distribution list by plant community. However, the latter source provided a considerable source of error in the distribution list. For example, Coulombe and Cooper (1976) incorrectly listed the foothill yellow-legged frog (*Rana boylei*) and the western arroyo toad (*Bufo microscaphus*) as expected to occur on VAFB. In addition, the presence of the California tiger salamander (*Ambystoma californiense*) was noted by Dial (1980), who stated that it had "been observed in the past in various locations along San Antonio Creek" but was not found during their field investigations. Currently the presence of California tiger salamander on VAFB has not been validated.

Biological surveys were performed by Human at San Antonio Terrace (1990) and San Antonio Creek (1987). Human (1990) described the biota of

approximately 6,000 acres of stabilized sand dunes and provided a map of more than 60 wetlands in this area. Human states that his surveys on San Antonio Terrace underrepresent the distribution and diversity of species because the investigations took place in a drought year, and because they were not performed at times appropriate to the target species. Also in 1990, wetland habitat was created at two sites on San Antonio Terrace as mitigation for the Peacekeeper Rail Garrison and Small ICBM Program (Earth Technology Corporation 1991). Five years of monitoring with annual reports provide a comprehensive description of vertebrate and vegetational changes, and contrast productivity between these and adjacent natural wetland sites (Earth Technology Corporation 1991, 1992, 1993, 1994, EARTH TECH et al. 1995).

Although Human (1987) performed San Antonio Creek surveys for amphibians in the season appropriate for their detection, reptile surveys were performed after many had become inactive. In addition, error in identification of amphibian and reptiles species is possible as some were based on tracks and vocalizations identified by descriptions in a field guide. Dial (1980) performed field observations at Barka Slough, and saw several species of reptiles, but was not as successful with amphibians. Other vertebrate surveys of San Antonio Creek listed just a few amphibian and reptile species (BioSystems Analysis 1991, see also Science Applications International Corporation 1994).

Observations of reptile and amphibian species in the lower Santa Ynez River were reported by Henningson et al. (1984a). In a more recent study, Hunt (1990) performed field investigations as well as a museum and literature search to determine vertebrate distributions on the Santa Ynez between the Lompoc Wastewater Facility and the 13th Street bridge on VAFB.

These data were also summarized by Santa Barbara County Flood Control and Water Conservation District (1990).

Various studies discuss management concerns of herpetofaunal resources of VAFB, but include no or very limited new field data (Mahrtdt et al. 1976, Oberbauer and Mahrtdt 1977, Dames and Moore 1984, U. S. Air Force 1984, 1987, 1990, Breininger 1988, Collins 1988, 1991, Engineering-Science 1988, McElligott 1989, Palermo 1989, MacConnell 1995a, 1995b, 1995c). Olson (1992) mentions vernal pools of Burton Mesa, VAFB, but includes no information about vertebrates in the area. Some data from amphibian surveys were given by Arthur D. Little, Incorporated (1987), but all are from sites outside of VAFB. Jalama Creek, of which a small segment is within VAFB, was included in a report of wildlife resources at Bixby Ranch (P. W. Collins 1990). This study involved field investigations, as well as a literature review and conversations with local biologists.

An interesting and informative report by Human (1991) detailed road kills (vertebrates and some invertebrates) observed on a route from Lompoc to San Antonio Terrace over a two-year period. Species maps are given, and tables of the number of kills per month.

1.2 Project Objectives

Previous work has not provided adequate information on the distribution of reptile and amphibian species on VAFB. Little was known about those species which are nocturnal, have a limited seasonal activity period, or which may occur in areas that are difficult to access. In addition, presence of the California tiger salamander and the western spadefoot toad (*Spea hammondi*) on the Base was expected, but not confirmed (Coulombe and Cooper 1976, Coulombe and Mahrt 1976, Mahrtdt et al. 1976, Oberbauer

and Mahrtdt 1977, Dial 1980, Henningson et al. 1984a and 1984b, Howald et al. 1985, Arthur D. Little 1987, Human 1987, Breininger 1988, McElligott 1989, Palermo 1989, Human 1990, Science Applications International Corporation 1994; see also U.S. Air Force 1984, Hunt 1990). Knowledge of the status of sensitive species on VAFB is critical for proper management.

Regionally rare or declining herpetofauna on VAFB are predominantly inhabitants of freshwater sites. The California tiger salamander and the western spadefoot toad are primarily inhabitants of vernal pools. The red-legged frog, and western pond turtle occur in ponds, lakes, lagoons and streams. The two-striped garter snake (*Thamnophis hammondi*) is usually found in streams, but may frequent ponds.

The aim of this study was to determine the distributions, habitat associations, and relative abundances of these sensitive aquatic reptile and amphibian species on VAFB. A secondary goal was to document the distributions of all amphibian and reptile species on VAFB by collection of voucher specimens (housed at the Museum of Systematics and Ecology, University of California, Santa Barbara), and preparation of maps detailing collection and sighting information. Previous to field investigations, a search of existing museum specimens collected at VAFB was performed by the author. Future goals include the addition of these data to the VAFB Geographic Information System currently being implemented by Delta Research Incorporated, Santa Maria, California.

2.0 SPECIES BACKGROUND

2.1 California Tiger Salamander

2.1.1 Taxonomy and Distribution

The California tiger salamander (*Ambystoma californiense*) is the only native species in this genus to occur on the coast of central California (Stebbins 1985). Formerly this taxon was thought to be a subspecies within *Ambystoma tigrinum* (Gehlbach 1967, Stebbins 1985), but evidence suggests that the western form is a full species (Jones 1989). Larvae of the introduced blotched tiger salamander (*A. t. melanostictum*) have been found at irrigation ponds within 7.3 km of VAFB (Sam Sweet, personal communication).

The range of the California tiger salamander is Sonoma County to western Santa Barbara County (Gehlbach 1967, McKeown 1974, Jennings and Hayes 1994a). It is found from near sea level to 1054 m (Shaffer and Fisher 1991). This taxon has been eliminated from the Central Valley due to agricultural and urban development (Stebbins 1985). The California tiger salamander has not been documented from VAFB, although it is known from sites approximately 16 km away (Ted Mullen, Science Applications International Corporation, personal communication). Intensive surveys of all potential habitat on VAFB failed to document the species, and it probably does not occur on the Base.

2.1.2 Life History

During dry periods, tiger salamanders aestivate deep underground in the burrows of ground squirrels, gophers, and badgers (Storer 1925, Stebbins 1985, Karen Pope, personal communication). When moisture is sufficient, tiger salamanders sometimes remain just under the surface so that they may

forage nocturnally above ground (Storer 1925). California tiger salamanders migrate as much as 1.6 km from refuge sites to breeding pools (Twitty 1941, Douglas and Monroe 1981, Austin and Shaffer 1992, Barry and Shaffer 1994).

The California tiger salamander breeds during the peak of winter rains, usually in January or February (Storer 1925, Twitty 1941, Stebbins 1985). During drought years, the salamander may not reproduce (Barry and Shaffer 1994). Spawning occurs in shallow temporary rain pools, one to two acres in surface area (Storer 1925, Twitty 1941). Occasionally it may breed in permanent waters of grasslands, or in low elevation woodlands (Stebbins 1985), if these sites lack fish (Shaffer and Stanley 1992). The larval period is approximately four months (Storer 1925), and neoteny is not known (Storer 1925, Gehlback 1967). Metamorphosis usually takes place in mid-May or early June (Storer 1925). Juveniles may forage at night for a short period before taking shelter underground to avoid desiccation during the dry season (Storer 1925, Zeiner et al. 1988). Mass emigration of post-metamorphic California tiger salamanders away from breeding ponds following a late summer storm has been documented (Holland et al. 1990).

2.1.3 Status

California tiger salamanders have disappeared from an estimated 55% of their historic range (Shaffer et al. 1993). Breeding pool and upland burrow sites have been modified as a result of agriculture and urban development in the Great Valley and the San Francisco Bay Area (Barry and Shaffer 1994, Jennings and Hayes 1994a, Stebbins 1985). Migration routes have been disrupted by physical barriers, such as walls and road dividers (Shaffer and Stanley 1992, Jennings and Hayes 1994a), and road crossings may result in

mortality (Barry and Shaffer 1994). This species is currently under consideration for listing as a federally endangered species (Long 1992).

2.2 Western Spadefoot Toad

2.2.1 Taxonomy and Distribution

The western spadefoot toad (*Spea hammondi*) was once thought to belong to *Scaphiopus* (Storer 1925, Stebbins 1985). However, osteological, ecological, and reproductive differences place it within *Spea* (Blair 1955, Kluge 1966, Tanner 1989). Geographically separated from *Spea multiplicata* by the Mojave and Sonoran Deserts, these species are differentiated from each other by a number of traits (Brown 1976). The western spadefoot toad inhabits elevations below 900 m in California and in northwestern Baja California, including the Central Valley and Coast Ranges south of San Francisco Bay (Stebbins 1985). In Santa Barbara County, this species is widespread but uncommon (McKeown 1974). It prefers areas with sparse vegetation, especially short grasses, and sandy or gravelly substrates (Stebbins 1985).

2.2.2 Life History

Adapted to arid climates, the western spadefoot toad spends most of the year underground to avoid desiccation. Adults emerge after the first heavy rains in the late spring or early summer (Storer 1925). During breeding season, spadefoot toads are active only at night, and return to underground retreats daily using spade-like structures on their hind limbs to burrow in loose soils (Storer 1925, personal observation). Spawning activity was observed on VAFB in late January - February (personal observation), near Santa Maria (Santa Barbara County) in early April, at Carrizo Plain (San Luis

Obispo County) in late May (Storer 1925), and in the Central Valley February through April (Brown 1976).

Eggs are laid in shallow temporary rain pools and ephemeral streamcourses (Storer 1925, Stebbins 1985) after water has warmed to at least 9° C (Brown 1967, Jennings and Hayes 1994a). Adapted to conditions of short-term water availability, development is remarkably rapid. Eggs hatch in less than a week (Brown 1967), and tadpoles reach metamorphosis in 3-11 weeks (Burgess 1950, Feaver 1971, Jennings and Hayes 1994a). Newly transformed spadefoot toads are capable of digging, and probably retreat to subterranean sites soon after they leave the water (Storer 1925).

2.2.3 Status

This species has been extirpated from most of the sites in southern California from which it was previously recorded (Stebbins 1985, Jennings and Hayes 1994a). Areas lost to development or converted to incompatible uses accounts for > 80% of spadefoot habitat lost in southern California, and > 30% of spadefoot habitat loss in central and northern California (Jennings and Hayes 1994a). It is listed federally as a Category 2 Candidate (Drewry 1994).

2.3 Red-legged Frog

2.3.1 Taxonomy and Distribution

In California, two subspecies of red-legged frogs occur: the northern red-legged frog, *Rana aurora aurora*, and the California red-legged frog, *R. a. draytonii*. These subspecies are separated morphologically, behaviorally, and possibly genetically (Hayes and Miyamoto 1984, Green 1985, Hayes and Kremples 1986).

Historically, the range of the California red-legged frog extended from the foothill drainages of the western Cascades and Sierra Nevada, across parts of the Great Valley through the coast ranges. It was present from sea level to approximately 1500 m (Stebbins 1985, Jennings and Hayes 1994a). Coastally, it was distributed from northwestern Baja California to Point Reyes National Seashore (Storer 1925, Altig and Dumas 1972, Stebbins 1985, Jennings and Hayes 1994a). From Mendocino County northward to the Oregon border, intergrades between the two subspecies are known to occur (Camp 1917, Hayes and Kremples 1986), and work is underway to characterize differentiation between the subspecies (Jennings and Hayes 1994a).

The California red-legged frog occurs throughout Santa Barbara County, with the exception of the Cuyama Valley, in streams, ponds, lakes, and reservoirs (Storer 1925, McKeown 1974, Stebbins 1985, Jennings and Hayes 1994a). Described as a pond frog, this species inhabits semi-permanent or permanent water (Storer 1925, Hayes and Jennings 1988, Rathbun et al. 1993). It is often found associated with deep stream pools bordered by willows and/or emergent vegetation (Jennings 1988, Hayes and Jennings 1988, Jennings and Hayes 1990, Rathbun et al. 1993).

2.3.2 Life History

Coastal populations of the California red-legged frog may not have a period of winter inactivity such as is experienced by inland populations (Storer 1925, Jennings et al. 1992). During winter rains this taxon may be found far from water (Stebbins 1985), and it has been observed under damp leaf litter in upland sites during November and December (Storer 1925, Rathbun et al. 1993). California red-legged frogs may also use crevasses or burrows in undercut stream banks during winter (Jennings et al. 1992).

This species breeds relatively early, November through March (Storer 1925, Hayes and Jennings 1986). Although Stebbins (1985) stated that the breeding period lasts only one or two weeks, on VAFB spawning activity was observed from early February through the end of March and calling continued into mid-April (personal observation). Eggs are usually laid among emergent vegetation or willows (Storer 1925, Jennings and Hayes 1990, personal observation). Four to five months are required for larvae to reach metamorphosis (Storer 1925). Postmetamorphic red-legged frogs were the most abundant in late July on VAFB (personal observation). In previous studies, survivorship from the egg to the postmetamorphic stage was found to be <1% (Jennings et al. 1992). Males reproduce after three years of age, and females after four years (Jennings et al. 1992). Males may live eight years, and females ten years (Jennings et al. 1992).

2.3.3 Status

The California red-legged frog has been proposed for listing as endangered under the Federal Endangered Species Act (Drewry 1994, Miller 1994). This species is absent from approximately 75% of its historic geographic range (Jennings et al. 1992). The most severe losses have occurred in the Central Valley, the foothills of the Sierra, and southern California (Stebbins 1985, Hayes and Jennings 1988, Jennings et al. 1992, Jennings and Hayes 1994a, 1994b).

In the late 1800's, California red-legged frogs were overharvested as a source of food (Jennings and Hayes 1984, 1985, Stebbins 1985). Due to depleted California red-legged frog populations, bullfrogs (*Rana catesbeiana*) were introduced to take their place in the market (Jennings and Hayes 1984, 1985). In addition, exotic species of fish and crayfish were introduced around the

turn of the century (Riegel 1959). Because bullfrogs, many species of exotic fish, and crayfish are efficient predators on one or more life stages of California red-legged frogs, it is unclear which has had the greatest impact (Moyle 1973, Hayes and Jennings 1986, 1988). Furthermore, alteration of habitat for flood management and by creation of reservoirs have favored these introduced species over California red-legged frogs (Hayes and Jennings 1986, 1988, Jennings 1988, Jennings et al. 1992). Feral pigs (*Sus scrofa*) occasionally prey upon amphibians, and negatively impact riparian vegetation during rooting and by creation of runs and wallows (Wood and Barrett 1979, Dial 1980, P. W. Collins 1990, Nee 1992). Because of these pressures and loss of habitat due to urbanization and agriculture, many remaining populations are severely fragmented and isolated (Hayes and Jennings 1986, Hayes and Jennings 1988, Jennings et al. 1992).

2.4 Western Pond Turtle

2.4.1 Taxonomy and Distribution

It is currently accepted that there are two subspecies of the western pond turtle based upon work by Seeliger (1945), but evidence exists that the systematics of this taxon should be re-evaluated (Holland 1991, Norman J. Scott, Jr., National Biological Service, personal communication). Conventionally, the northwestern pond turtle (*Clemmys marmorata marmorata*) occurs north of the Sacramento Valley, and the southwestern pond turtle (*C. m. pallida*) ranges from Monterey to Baja California (Stebbins 1985, Gray 1995). A zone of intergradation has been reported from the Central Valley from the San Francisco Bay to the foothills of the Sierra Nevada (Seeliger 1945, Bury 1970, Stebbins 1985). It occurs from sea level to approximately 1800 m elevation (Stebbins 1985). In Santa Barbara County, it is

moderately common in streams, ponds, lakes, reservoirs, and freshwater sloughs (McKeown 1974).

2.4.2 Life History

Western pond turtles are highly aquatic, and prefer lentic waters with logs, mats of vegetation, or other suitable basking sites (Stebbins 1985, Holland 1991). Pond turtles may overwinter in water or on land up to 450 m away from water (Rathbun et al. 1993). Due to relatively warmer temperatures experienced by populations on the central and south coast of California, southwestern pond turtles may be active year-round (Holland 1991, Rathbun et al. 1993). Mating usually occurs in April or May, but may occur throughout the year (Holland 1985, 1991). Eggs are laid in nests in upland areas 16 to 400 meters from water, usually in May and June, but oviposition may occur any time from April to August (Storer 1930, Holland 1985, 1991, Jennings et al. 1992, Rathbun et al. 1992, 1993). Hatchlings may overwinter in the nest and move to aquatic sites in March or April (Jennings et al. 1992). Depending on latitude, southwestern pond turtles become reproductively mature between 7 and 11 years of age (Jennings and Hayes 1994a). Turtles trapped on VAFB in 1995 appeared to be of mature size at 3-8 years of age, depending on locality (Germano 1995). Southwestern pond turtles are extremely long-lived, and one individual was known to be at least 42 years old (Jennings and Hayes 1994a).

2.4.3 Status

The southwestern pond turtle is listed federally as a Category 2 Candidate (Drewry 1994). In general, most of the historic range is still occupied, but population sizes have declined, and recruitment may not occur

at some sites (Jennings et al. 1992, Jennings and Hayes 1994a). Substantial numbers of southwestern pond turtles were exploited for food from the late 1800's through 1920's (see Jennings et al. 1992). Habitat alteration such as water diversions, creation of reservoirs, channelization for flood control, urbanization, grazing, and drought have negatively affected southwestern pond turtles (Brattstrom 1988, Jennings et al. 1992). Introduced predators, especially bullfrogs, bass (*Micropterus* spp.) and catfish (*Ictalurus* spp.), are also suspected to consume hatchling and juvenile pond turtles (Moyle 1973, Jennings et al. 1992, Jennings and Hayes 1994a). Introduced carp (*Cyprinus carpio* and *Carassius auratus*) may modify habitat through disturbance of emergent vegetation, while sunfish (*Lepomis* spp. and *Pomoxis* spp.) and catfish may compete with turtles for food (Jennings et al. 1992). Direct effects of humans, such as illegal collecting, accidental catch by fishermen, and mortality due to vehicular traffic during overland movements also take their toll on southwestern pond turtles (Jennings et al. 1992, Jennings and Hayes 1994a, personal observation). Fragmentation of habitat and resulting isolation of populations has probably impeded re-establishment from adjacent areas.

2.5 Two-Striped Garter Snake

2.5.1 Taxonomy and Distribution

Once part of the *Thamnophis couchii* complex, the two-striped garter snake (*T. hammondi*) is currently recognized as a full species (Lawson and Dessauer 1979, Rossman 1979, Rossman and Stewart 1987). In the central coast of California, there are four sympatric but distinct species of garter snakes: *T. hammondi*, *T. atratus*, *T. elegans*, and *T. sirtalis* (Bellemin and Stewart 1977, Rossman and Stewart 1987, Boundy 1990).

The two-striped garter snake occurs west of the San Joaquin Valley and southern deserts, from Monterey County to La Presa, Baja California, Mexico (Stebbins 1985, McGuire and Grismer 1993). It is present from sea level to approximately 2100 m in elevation (Stebbins 1985).

2.5.2 Life History

This highly aquatic snake is usually found in summer near permanent fresh water, especially streams with rocky substrate and a willow border (Fitch 1941, Stebbins 1985, Rathbun et al. 1993). It is active during the day and at night (Stebbins 1985, personal observation). In winter two-striped garter snakes occupy upland grassland or coastal sage scrub, and have been found 50 - 180 m from water (Rathbun et al. 1993). While mostly inactive in rodent burrows during winter, they may forage occasionally on warm days (Rathbun et al. 1993). Two-striped garter snakes usually mate during March, and the young are born August through November (Stebbins 1985, Rathbun et al. 1993, Jennings and Hayes 1994a). These snakes reach sexual maturity at around 2 to 3 years of age, and in captivity, individuals have lived 7 to 10 years (Jennings and Hayes 1994a).

2.5.3 Status

The two-striped garter snake is listed federally as a Category 2 Candidate (Drewry 1994). It has been eliminated from approximately 40% of its historic range, with most of the reduction occurring since 1945 (Jennings and Hayes 1994a). Habitat modifications such as urbanization, flood control practices, creation of reservoirs, and effects of livestock grazing have played a major role in the decline of this species (Jennings and Hayes 1994a). Introduced

fishes, bullfrogs and feral pigs prey upon the garter snake, and probably have contributed to its decline (Jennings and Hayes 1994a).

2.6 Other Sensitive Reptiles on Vandenberg Air Force Base

2.6.1 Coast Horned Lizard

The California horned lizard (*Phrynosoma coronatum frontale*) is differentiated from the southern subspecies *P. c. blainvillii*, the San Diego horned lizard (J. T. Collins 1990), and some have argued that these are two distinct species (Klauber 1936, Smith 1946). It is distributed west of the Cascade-Sierran ridge below 1950 m, from the Sacramento Valley south to Ventura and northern Los Angeles Counties (Bryant 1911, Smith 1946, Stebbins 1985, Jennings and Hayes 1994a). The greatest number of populations of California horned lizards have been recorded from Santa Barbara County (Jennings and Hayes 1994a). It occurs in most habitats present on VAFB (McKeown 1974, Stebbins 1985). Adult horned lizards are most active in April and May, and juveniles emerge in July and August (Banta and Morafka 1968). Critical habitat features are open areas for basking and loose substrates for borrowing (Stebbins 1985). This species was observed on VAFB during surveys performed during 1995, but a concerted effort to document its distribution on the Base was not performed. It is listed federally as a Category 2 Candidate (Drewry 1994).

2.6.2 California Legless Lizard

The California legless lizard (*Anniella pulchra*) ranges west of the Sierra Nevada foothills from Contra Costa County to San Diego County (Hunt 1983). Although a nomenclatural rearrangement to *A. nigra* was proposed (Hunt 1983), it has not been followed due to its destabilizing effect

(Murphy and Smith 1985, 1991). This fossorial species burrows in sandy substrates, and is surface active mainly in the morning and evening (Miller 1944). Legless lizards were found at VAFB in April 1995 and April 1996 (personal observation; Mark Holmgren, University of California, Santa Barbara, personal communication). Young are born from September to November (Miller 1944). Habitats used include sparsely-vegetated chaparral, pine-oak woodland, and riparian woodland on stream terraces (Banta and Morafka 1968, Stebbins 1985). It is listed federally as a Category 2 Candidate (Drewry 1994).

3.0 METHODS

3.1 Habitat Identification

Preliminary coarse-scale mapping of freshwater habitats was performed in summer 1994. From December 1994 through September 1995, an attempt was made to identify all freshwater sites on VAFB, with the exception of a few of the numerous dune swale ponds of San Antonio Terrace. Almost all of the ponds east of Southern Pacific Railroad (SPRR) tracks were mapped, but ponds west of the tracks were not explored to prevent disturbance of nesting least terns (*Sterna albifrons*). Use of topographic maps, aerial photographs, VAFB literature, VAFB C-TAB maps produced by Delta Research, Incorporated (Santa Maria, California), communications with Base personnel (Nancy Read, Wildlife Biologist; Chris Gillespy, Botanist) and other biologists (Norman Scott, Jr., National Biological Service; Mark Holmgren, University of California, Santa Barbara; Paul Collins, Santa Barbara Museum of Natural History) augmented field reconnaissance. Many pools were found by listening for the calls of Pacific chorus frogs (*Pseudacris regilla*). Vernal pools,

ponds and lakes were given numbers (Table 1) and mapped (Figure 2). Stream reaches surveyed are also given in Table 1 and Figure 2.

3.2 Visual Surveys

All sites were visited at least once during the day. If the site was more than a rain puddle or a small rivulet, a visual survey at night was also conducted. Sites were visited from 1 to 16 times over the period from December 1994 - September 1995 (Table 2). Sites with high frequency of survey are mainly those which were used out of convenience to demonstrate survey technique and species identification to other wildlife biologists, and sites such as road crossings which were checked routinely en route to other areas. In addition, turtle traps were checked daily for as many as three days, and each visit to check traps was counted as a visual survey. The amount of survey time for each site was summed for all visits (Table 2). These sums represent the product of the number of minutes surveyed and the number of people actively engaged in visual survey (visual survey only - netting and boating are counted separately).

During each survey, numbers of amphibians and reptiles observed was recorded, grouped by life stage. If a positive visual identification could not be made due to the animal fleeing, or if it was in an area that approach close enough for identification was not possible, it was recorded as "unidentified frog" or "unidentified ranid frog". No guesses were made, such as, "I've only seen red-legeds here, so that's what it must be". Identifications made by assistants were confirmed by the author until the assistants had sufficiently demonstrated their accuracy.

Data recorded at the beginning and end of each survey included the time, air temperature, water temperature, cloud cover and wind speed. Temperature was

measured using a hand-held thermometer and the other weather data were estimated. For western spadefoot toads, red-legged frogs, western toads (*Bufo boreas*), bullfrogs, and two-striped garter snakes, parameters describing microhabitat use for each animal were recorded. These included dominant types of aquatic and bank vegetation, substrate, flow (pool, riffle, glide, etc.), maximum water depth within 0.5 meter of animal, width of wetted stream channel, width of active stream channel, pool length, and canopy cover. Special attributes and locations were recorded in the "notes" section. A copy of the data sheet and the key for its use are included in Appendices A and B. Analysis of microhabitat usage will be performed subsequent to the issuance of this report.

3.2.1 Vernal Pools

Visual surveys of vernal pools were performed by one or more observers by wading around the perimeter and walking transects across the pool. Larval and recently-metamorphosed ("metamorph") western toads and Pacific chorus frogs could be readily identified during day surveys. California tiger salamanders were also searched for. Night surveys were performed using high-powered lights (Wheat Cap Lamp, Koehler Manufacturing, Marlborough, Massachusetts) to detect eyeshine. Night surveys revealed adult western spadefoot toads, adult western toads, and adult and metamorph Pacific chorus frogs. Listening for spadefoot calls aided in identifying breeding populations. Vernal pool survey times are given in Table 2.

3.2.2 Ponds, Lakes and Lagoons

Habitat was surveyed both during day and at night since red-legged metamorphs are generally active during the day, and adults are mainly nocturnal. When water exceeded the depth of our waders (approximately 1

m), a float tube boat or canoe were used. In most permanent lentic habitats on the Base, there is a dense band of emergent vegetation encircling the pond. In these situations, both the perimeter of the pond was searched by wading through the reeds, and the inner edge of the reeds and the open water were searched by boat.

The upper Santa Ynez River Lagoon was surveyed by canoe. Shuman and San Antonio Lagoons were surveyed by float tube. Jalama Lagoon was shallow enough to wade across most areas.

The total time of visual, tube boat and canoe surveys is shown in Table 2.

3.2.3 Streams

The sections of streams surveyed were mostly based on where we could gain access. Dense brush (especially stinging nettle and poison oak), steep eroded banks 5 to 20 meters high, and lack of animal paths precluded easy access to many stream reaches. Trails were cleared to gain entrance to streams, or road crossings were used.

Day surveys and subsequent night surveys using lamps described above were performed. The Santa Ynez River was wide enough for each observer to cover one side of the river. In other streams, the author was followed by one other observer. Some streams stretches were walked through on one pass, while others required a return trip back down the stream. In instances where the same return route was taken, sightings were not counted unless we were certain that we were not recounting the same individual (e.g. it was spatially separated from other recorded sightings). The amount of total time which is the sum of the actual amount of survey time for stream surveys is given in Table 2.

3.3 Seining

Vernal pools and some permanent ponds were searched by hauling a seine stretched between two people. The seine had 4 mm mesh, was 1 m in width, and was extended to about 3 m long depending on habitat. If vegetation was sparse, this method was effective in catching spadefoot and red-legged tadpoles. Individual seine runs attempted to survey different microhabitats (such as shallow edge, deep with emergent grasses, deep without vegetation, etc.). Habitat parameters were recorded for each run with the number of tadpoles caught. The total time spent seining each site is given in Table 2.

3.4 Dip Netting

Dip nets were effective for sampling tadpoles and fish in vernal pools, ponds, lagoons, and stream pools. In areas with dense aquatic vegetation or flooded upland shrub (which was common this year), dip nets were more efficient than the seine. The dip nets used were D-ring with diameter 0.4 m and 1 mm mesh. The dip nets were dragged along the bottom as the observer walked through a patch of relatively homogeneous microhabitat. Habitat data and catch were recorded for each patch. A swift sweep was effective at netting fleeing larvae in shallow water. Red-legged frog tadpoles could be caught by carefully placing the net vertically in the water, and flushing the animal into the net. The total amount of time conducting dip net surveys at each site is shown in Table 2.

3.5 Tadpole Trapping

Unbaited minnow traps (Cuba Specialty Manufacturing Company, Incorporated, Fillmore, New York) were used to sample tadpoles from April

through August (Figure 3). Incidental catch in the traps were fish, red-legged frog metamorphs, and two-striped garter snakes. Because we caught the latter two species, minnow traps in permanent ponds and streams were supported on a vegetative brace or placed in shallow water in order to leave an air space in the trap. If the habitat at a given site was extensive enough, eight traps were set at a time. In permanent ponds and streams, we had the greatest success trapping red-legged tadpoles if the traps were set in the early afternoon and checked in the evening. The traps were systematically placed in an equal number of edge and inner-edge habitats (approximately 5 to 10 meters from shore). This systematic placement was used in vernal pools, but at the "deep" sites the traps were completely submerged. In vernal pools, traps were set only during daylight, for an average 4.5 hours. We found if traps were set for much longer, there was considerable loss of tadpoles due to predation by beetle larvae which were also caught in the traps. If the traps were left submersed in deep water at night, we lost tadpoles apparently due to lack of oxygen.

Habitat parameters described in the visual survey section were recorded at each trap. Traps were emptied into a plastic bucket to aid in counting tadpoles. Fish caught were also identified and counted. A measure of minnow trapping effort at each site was calculated as the product of the number of minutes the traps were set and the number of traps (Table 2).

3.6 Turtle Trapping

Turtles were seldom observed basking unless they could be seen from a distance with binoculars, so trapping proved the most effective method of sampling. Turtle traps often caught more large red-legged frog tadpoles than were obtained using the minnow traps. In addition, adult and metamorph

red-legged frogs were occasionally entrapped. Traps used were coated fishing net pulled over four 0.5 m diameter fiberglass hoops (Nylon Net Company, Memphis, Tennessee). Two conical throats prevented animals from escaping (Figure 4). Traps were baited with Seacliff sardines (in oil), and a styrofoam float provided an air space.

In permanent ponds, lakes, and lagoons usually four traps were set for approximately 72 hours. In streams with a shortage of pools > 0.3 meters deep (needed to immerse the throats), fewer traps were set. In ponds, lakes, and lagoons the traps were placed systematically within 6 meters of the shore. Placement of traps was not random in streams as they needed to be set in deep pools. In deep water, the traps were transported using a "boogie board barge" pulled behind the float tube. The traps were checked once a day, and the bait was not replaced. Numbers of turtles, frogs, and tadpoles, and habitat parameters described in the visual surveys section were recorded for each trap. A measure of the turtle trapping effort at each site was calculated by the product of the minutes the traps were set and the number of traps (Table 2).

3.7 Calculation of Relative Abundances

For each site, the sum of individuals of each species that were seen during all visual surveys or caught in traps was calculated. However, since some sites were visited more than once, the same individual may have been counted more than once. Therefore, comparisons of sums could not be made between sites. Comparisons may be made between average number of animals seen for all surveys at a given site. Means were calculated if surveys were performed more than once in an identical fashion. However, the best measure of abundance for comparisons between sites is the maximum individuals seen during any one survey.

The maximum values were used in the calculation of relative abundances. For amphibians and reptiles that were sampled through visual survey, relative abundance values were calculated by the maximum number seen divided by the person-minutes of survey time from the one survey that generated the maximum value. The measures of relative abundance of tadpoles and turtles were calculated by the total caught within a 24-hour trapping period divided by the product of the number of traps and the minutes the traps were set.

The number of amphibians sighted during visual surveys is dependent upon physical features of the habitat, which influence an observer's success of seeing what is actually there. For example, a survey from a shallow pond lacking vegetation may yield a relative abundance value higher than that of a deep, densely-vegetated pond which is technically difficult to move around in or in which frogs are concealed. Relative abundance values would infer incorrect information about actual population sizes if comparisons were made between sites with different habitat complexity. Therefore, sites were grouped into habitat categories, and relative abundance values should be compared only between sites within a category.

Even with habitat grouping, caution is strongly advised for interpreting relative abundance values. These values provide a very crude and possibly completely inaccurate approximation of population size. Visual sampling results are dependent on the activity of the animals, which is influenced by temperature, humidity, disturbance, seasonality, etc. The more a site was sampled, the stronger confidence can be ascribed to maximum values.

3.8 Systematic Habitat Sampling

Presence/absence and relative abundance data from traps were evaluated based on habitat differences between sites. Two methods generated equivalent random measures of habitat: data collection from the trapping effort and systematic habitat sampling. The portion of vernal pool habitat that was sampled represented areas where amphibians would potentially occur (i.e. the middle unvegetated zone with water depth > 0.4 m was not sampled). A tube boat was used to sample habitat of large ponds and lakes. Sampling stations were chosen for each site using fixed compass points, to account for the characteristically different features of the western and eastern shores of dune swale ponds. The tube boat permitted measurement of maximum and near shore pond/lake depth. In streams, habitat parameters were sampled at each reach in which herpetofaunal surveys were performed.

At each site, habitat parameters were sampled at six systematically chosen stations, and means were calculated. At each station, the following measurements or estimates were made: 1) Percent cover of dominant aquatic vegetation types within m^2 quadrat, 2) Percent intercept of dominant bank vegetation types along a 10 m transect perpendicular to shore, 3) Percent composition of dominant substrate types, 4) water depth, and 5) canopy cover measured with a convex mirror which performed in a fashion similar to a densiometer. Length and width of each vernal pool, pond, or lake was measured with a fiberglass tape, estimated from pacing, estimated visually (with surprising accuracy), or clocked on a vehicle odometer. Stream width was measured or estimated at each station.

The group of sites with a given sensitive species present were contrasted against the group of similar sites with that species absent using multiple discriminant analysis to predict the most important habitat

parameters. Differences of means for important habitat parameters were analyzed using Student's independent *t*-tests and were displayed graphically.

3.9 Red-legged Frog Tadpole Measurements

Since the breeding period for red-legged frogs on VAFB was longer and extended later in the season for streams sites than for ponds (personal observation), differences in tadpole size and stage of development at a given time were to be expected between sites. As total length of tadpoles decreases at a different rate than the increase of hind leg length, both were measured. Tadpoles which metamorphose at a larger size, and hence are larger as metamorphs, may reach reproductive maturity sooner and thus have higher fitness (Semlitsch 1987, Wilson and Lefcort 1993). Late summer measurements of tadpole total length and length of hind legs were determined using a handheld ruler. Areas sampled were ponds 27, 30, 63, and Jalama lagoon, San Antonio lagoon, and Shuman lagoon. Large numbers of tadpoles were obtained from only two sites: pond #27 and Jalama lagoon. A Student's independent *t*-test was conducted for difference of means of tadpole total length and tadpole hind leg length between pond #27 and Jalama lagoon.

4.0 RESULTS

4.1 Distribution and Relative Abundance

A list of all reptile and amphibian species encountered during 1995 field investigations is given in Table 3, and a complete set of distribution maps is contained in Appendix C. Distributions of sensitive and some common taxa are discussed below.

Survey and trapping totals, means, and maximum values for western spadefoot toads, red-legged frogs, bullfrogs, western toads, Pacific chorus frogs, western pond turtles, and two-striped garter snakes are given in Tables 4 through 7. Relative abundances grouped by habitat are presented in Table 8. Sites in Tables 4 through 8 can be indexed in Table 1 and located on maps in Figure 2.

4.1.1 California Tiger Salamander

The California tiger salamander was not found on VAFB, despite repeated searches of essentially all suitable habitat performed during potential breeding and larval periods. This taxon is known from sites near VAFB. It is documented from approximately 4 kilometers south of Betteravia (Ted Mullen, personal communication), Santa Rita Valley on Hwy. 246, Cañada de las Flores near Hwy. 101, and Bradley Canyon near the town of Garey (see Appendix D).

4.1.2 Western Spadefoot Toad

The largest populations of western spadefoot toad on VAFB probably occur on Burton Mesa, especially in the vicinity of the Main Administrative (Cantonment) Area (Table 4 and 8, and Figure 5). Adult toads were seen during rainy nights on New Mexico Avenue apparently moving between upland sites and breeding pools. Some of these suffered mortality due to vehicular traffic. Breeding occurred in the excavated pool southeast of New Mexico Avenue (#18) (Figure 6), a pool adjacent to 26th Street (#51), and in the largest vernal pool on Base (#34) (Figure 7) through which Tangair Road runs.

Spadefoot toads were also present on San Antonio Terrace. Breeding occurred in a temporary dune swale pond on the eastern edge of most landward active dune (#59 in Figure 5) (Figure 8). A lone spadefoot was found on a rainy night far from any ponds on El Rancho Road (Figure 5).

4.1.3 Red-legged Frog

Since red-legged frogs were found in almost every pond with summer water depth > 0.6 meter (Figure 9), it is useful to discuss the areas in which they were not observed. The most interesting area from which they were absent was Pine Canyon Lakes (#45). Literature reviewed and personal communications indicate that red-legged frogs have not occurred in Pine Canyon Lakes since at least the mid-1970's, despite their presence in the lower portion of the drainage (Christopher 1995) and apparently structurally suitable habitat. Two sites that had maximum depth 0.7 meter, ponds #31 and #42, lacked red-legged frogs. These two ponds are more than 3 km from sites with red-legged frogs, and both probably dried up during recent drought years. Lake #41 lacked red-legged frogs despite very deep water present this year; however, in previous years this lake was dry (Jim Watkins, U. S. Fish and Wildlife Service, personal communication). Site #69 is wastewater ponds with unknown depth; no aquatic life was seen at this site. Pond #23 may be too saline for amphibians since it lacked calling Pacific chorus frogs during the peak of their breeding season. When created duck ponds (#48) were surveyed in late May, all but one were dried up due to pump failure (Allan Naydol, VAFB Chief of Natural Resources, personal communication) and no red-legged frogs were seen. It is possible that if deep water levels were maintained in other years this site could support adult red-legged frogs.

However, due to the large number of bullfrogs observed, successful reproduction of red-legged frogs may not be great at this site.

Due to the relative difficulty of surveying pond #58 (from depths > 1 meter at water's edge and vegetation too dense for the tube boat) no frogs were seen, but it is likely that they occur because of habitat suitability and proximity to San Antonio Creek. Pond #89, which was discovered after surveys were completed, and other ponds which may occur west of SPRR tracks, are highly likely to have red-legged frogs since the density of red-legged frogs on San Antonio Terrace is high and dune swale ponds appear to provide excellent habitat free from introduced predators. Access to pond #84 was not possible for a night survey, since it is accessible only through private property. Because a red-legged metamorph was seen < 1 kilometer away (pond #83) and because the habitat looked suitable, red-legged frogs are likely to be present in #84. Red-legged frogs were heard calling in pond #37 below the beaver dam, but despite several attempts to spot them from the shore, none were seen (Table 5) and lower pond #37 had vegetation too dense for effective use of the tube boat.

Every perennial stream had red-legged frogs, except for the relatively smaller streams of Sudden Ranch (Figure 9). The exception was Cañada del Jolloru, which appeared similar in habitat to the innominate "near Pt. Sal" stream (see maps in Figure 2). No red-legged frogs were seen at Cañada del Jolloru, but one was seen at "near Pt. Sal". The pond at the mouth of Cañada del Jolloru appear suitable for red-legged frogs, but upstream of the SPRR crossing livestock grazing has resulted in erosion, decreased vegetative cover, and thus little adequate habitat. Shuman Creek had red-legged frogs in two areas: the lagoon and immediately downstream from the confluence of Casmalia Creek. In San Antonio Creek, red-legged frogs were found at every

location checked, except for the reach between the crossing of San Antonio Road West to 1.5 km west of the crossing of Hwy. 1. This stretch was shallower (no pools deeper than 0.2 meter) than the other reaches surveyed. Although almost the entire length of the Santa Ynez River was surveyed on VAFB (Figure 2), red-legged frogs were found in only two areas (Figure 9). Hunt (1990) noted red-legged frogs at the crossings of 13th Street and Floradale Road, but since spring 1995 floods altered channel morphology (personal observation), it appears that pools that may have been near 13th Street were lost. Surveys were not performed at Floradale Road, but habitat appeared suitable for red-legged frogs. Cañada Honda also experienced loss of pools from the 1995 floods (Figure 10). Adult red-legged frogs were present up to 1.1 km east of the Pacific Ocean in summer 1994 (Christopher 1994). In 1995, adults were found only at deep pools near the SPRR bridge pilings, and a single adult frog was seen in the upper one-third of the stream. Metamorphs were abundant in the middle reaches of Cañada Honda. Lower Cañada Honda was surveyed, dip netted or trapped three times from May to July, and the only pre-adult red-legged obtained was one tadpole at the lagoon. However, in September several metamorphs were present immediately below the crossing of Coast Road and one was found approximately 0.3 km above the crossing. These metamorphs may have emigrated into this area from upstream breeding pools. Adult red-legged frogs and larvae occurred in Jalama lagoon to at least 200 m upstream of the SPRR trestle.

The two dune swale ponds with the highest relative frequency values for adult red-legged frogs were those created five years ago as mitigation for the Peacekeeper Rail Garrison Project, sites #26 and #27 (Table 8, see Earth Technology 1991-1995). However, the maximum number of red-legged frogs observed during one survey was much greater for dune swale ponds #71 and

#78 than for the created ponds (Table 5). Reproduction of red-legged frogs in dune swale ponds appeared to be most successful in ponds #47 and #27 (Table 5). However, comparisons between #47 and other dune swale ponds should not be made because these tadpoles were obtained through seining, while the others were trapped. Furthermore, to obtain a large sample for tadpole measurements, twenty-four traps were set in pond #27. Of these, one well-placed trap produced twenty-seven tadpoles and two metamorphs (Figure 3).

In the small permanent ponds category, pond #73 had the highest relative frequency of adult red-legged frogs (Table 8). Seven adult red-legged frogs were seen during one night survey (Table 5), plus seven more unidentified ranids. Red-legged metamorphs were abundant in pond #63, although adult frogs were never seen (Tables 5 and 8). Pond #73 and pond #85 both produced 4 tadpoles for the same number of traps (Table 5), but relative frequency values differ due to leaving those in #73 for a longer period of time (Table 8). It is of interest that both pond #73 and pond #63 are in very dense stands of bluegum eucalyptus (*Eucalyptus globulus*) (Figure 11).

Despite previous cautions against comparisons between categories, it is of importance that the two lakes in the "sparsely vegetated large permanent pond" category had higher maximum counts of red-legged metamorphs than any other site. Thirty-nine were seen during one visit to pond #60, and 30 were seen during a survey of #87 (Table 5). Tadpoles were also very abundant in pond #60, with 86 caught in a session with 4 traps set (Tables 5 and 8). The site with the second highest number of tadpoles was dune swale pond #27, with 60 tadpoles caught in 24 traps.

Large bodies of water with dense vegetation were the most difficult to survey successfully. Red-legged frogs were heard calling from, but never spotted in Punchbowl Lake, #46 (Table 5). Red-legged frogs were located by

their calls on two occasions in pond #30, but surveys subsequent to their calling period failed to detect the species. Reproduction of red-legged frogs was relatively successful in Mod III Lake, #39 (Table 8).

Of all the lagoons on Base, San Antonio had the highest number of adult red-legged frogs (Tables 5 and 8). Cañada Honda lagoon had the greatest number of metamorphs seen which occurred during the September survey; these may have emigrated to the lagoon from upstream (see discussion above). Certainly the most productive lagoon for red-legged tadpoles was Jalama (Table 8). Total number of tadpoles at Jalama in Table 5 represents the sum of tadpoles caught in minnow traps, turtle traps, plus those dip netted or directly observed. Dip netting and direct observation were not feasible at the other lagoons due to greater depth and water turbidity.

Evaluation of stream sites among all other classes except lagoons shows that the highest relative frequency for adult red-legged frog sightings occurred at road crossings (Table 8). Two sites on San Antonio Creek had higher relative frequencies of adult red-legged frogs than at the other creeks. It is interesting that reproduction in streams was poor, with no tadpoles obtained from any of the reaches upstream from lagoons. This may be due to tadpoles having been washed out during high discharge from late-winter storms, or related to the fact that most reaches upstream of lagoons did not have much suitable breeding habitat (Cañada Honda Cr., Shuman Cr., and Santa Ynez River), or had abundant introduced predators (San Antonio Cr. and Santa Ynez River).

4.1.4 Bullfrog

Bullfrogs occurred in permanent and ephemeral systems in the drainage basins of the Santa Ynez River and San Antonio Creek (Appendix

C). They occur in the three lakes that have been stocked for recreational fishing (Coulombe and Cooper 1976), Mod III (#39), Punchbowl (#46), and Pine Canyon (#45). Bullfrogs were found in a fraction of ponds within 1 km of San Antonio Creek: #38, #61, and #83. As mentioned above, pond #84 was not surveyed at night, so it is not known if bullfrogs occur there. Bullfrogs were present in San Antonio Creek at and above the Lompoc-Casmalia Road crossing to Hwy. 1. Many visits to the El Rancho Road crossing were made during bullfrog breeding season, and no calls were heard, and all ranid frogs that could be identified from the bridge were red-legged frogs. Bullfrogs did not occur in the dune swale ponds of San Antonio Terrace.

Bullfrogs are apparently better established in the Santa Ynez River and its tributaries than in lower San Antonio Creek (Appendix C). Bullfrogs in Pine Canyon Lakes (#45) and in the Santa Ynez River were larger in body size and more abundant than anywhere else on Base (personal observation). They were found in two ponds (#67 and #48) that were relatively large in the spring, but dried up in summer. Four others (northern #30, eastern #36, eastern #68, and #66) were close to drying up in late summer, and probably do not persist in years with average rainfall. Well-distributed throughout the Santa Ynez River proper, bullfrogs probably do not inhabit the lagoon. The lagoon sighting, which occurred in spring, may have been the result of frogs washed down during flooding (Paul Collins, Santa Barbara Museum of Natural History, personal communication).

Of all the ephemeral ponds, bullfrogs were most abundant in created duck ponds at site #48 (Table 8). Bullfrogs were also numerous at site #36, especially in the deeper western pond. Bullfrog abundance was nearly evenly distributed among the three San Antonio Creek sites (Table 8). They were

more abundant near the 13th Street bridge than at other locations on the Santa Ynez (Table 8). The highest relative frequency of bullfrog sightings was San Antonio Creek at the crossing of Lompoc-Casmalia Road (Table 8), but the actual maximum number of individuals seen was two, and they were collected for future stomach content analysis (Table 6).

4.1.5 Pacific Chorus Frog

Pacific chorus frogs are by far the most abundant and widely distributed anuran on VAFB. Their distribution essentially matches the distribution of freshwater resources on VAFB in 1995 (Appendix C). The mapped distribution probably underrepresents their actual distribution, since this taxon can breed in pools smaller than those which were the focus of this study. Pacific chorus frogs make overland movements, especially on rainy nights, and were often observed on roads (Appendix C).

The greatest number of chorus frogs seen during single surveys were in vernal pools in early spring. The greatest number of adult chorus frogs were found in pools #44, #14, and #7 (Table 7). Of all permanent ponds, dune swale ponds #72 and #71 had the greatest number of adult chorus frogs. It should be noted that these dune swale ponds were surveyed much after the peak of chorus frog breeding, while the vernal pools were surveyed during the peak. Pacific chorus frogs also favored lagoons over the upper portions of streams (Table 7). Jalama lagoon had the highest maximum number of chorus frogs observed, followed by San Antonio lagoon and Shuman lagoon. Chorus frog metamorphs can reach very high densities in relatively small ponds. Ponds #74 and #85 had 133 and 100 metamorphs on a single survey, respectively (Table 7). Vernal pools #31 and #34 also had high numbers of chorus frog metamorphs. In lotic environments, smaller and more

ephemeral stream habitats were the most successful for chorus frog reproduction as seen by maximum numbers of metamorphs. The unnamed stream "near Pt. Sal" had the greatest number of chorus frog metamorphs (113) of any stream. The middle portion of Cañada Honda, Bear Valley, and Cañada del Jolloru also had relatively high chorus frog reproduction.

4.1.6 Western Toad

The western toad was found throughout VAFB, with the exception of vicinity of Shuman Canyon (Appendix C). They have not been recorded from Shuman Canyon in the literature or by museum specimen, but nevertheless may occur in this area. Toads were often seen on roads at night, and many suffered mortality due to crushing by vehicles. At the peak of breeding, 8 toads were seen in the excavated pool at site #18 (Table 7), but usually only 1 or 2 adult toads are seen at a time. Metamorphs were found in high densities at breeding sites. At pool #80, 50 metamorphs were seen during a single survey, and 45 were seen at Jalama lagoon. Toad tadpoles also tended to occur in extremely high densities. Tadpole trapping at created wetland #26 produced approximately 1829 western toad tadpoles from 8 minnow traps, and hundreds more were observed. The total number (1045) at Jalama lagoon was estimated from two visual surveys. Sites with over 100 toad tadpoles include pools #18, #35, #41, #44, and Honda lagoon (Table 7).

4.1.7 Western Pond Turtle

The western pond turtle was found in the drainage basins of San Antonio Creek, Santa Ynez River, Cañada Honda, and Jalama Creek (Figure 12). All of the ponds and stream pools that they occupied had water depths

> 0.5 meter with two exceptions: a hatchling found at San Antonio Creek between Richmond Road and Hwy. 1 crossings, and an adult at irrigation pond #83. Turtle tracks were seen at "San Antonio Turtle Marsh" (Norman Scott, National Biological Service, personal communication) (Figure 2), but the marsh remained dry after these tracks were discovered. Turtles were found along the middle reaches of Cañada Honda, and it is surprising that none were obtained from the lagoon. Several turtles were seen, but not captured for identification, in a wastewater pond at the U. S. Federal Penitentiary. It is possible but highly unlikely that these were an introduced species, due to the relatively large number seen (Christopher 1995). The non-native slider (*Trachemys scripta*) was collected from pond #38, so identifications not made in hand may be unreliable. Fortunately, with the exception of the Penitentiary site, western pond turtles were confirmed at all localities given in Figure 12. Since only one slider was trapped, and its shell had recently been painted by someone, it is believed that this indicates a single released individual and not a member of a self-sustaining population.

The most productive sites for turtle trapping proved to be Punchbowl Lake (#46), Jalama lagoon, and Pine Canyon Lakes (#45), with 51, 18, and 12 maximum turtles trapped, respectively (Table 4). Punchbowl Lake and Jalama lagoon also had the highest relative frequency values (Table 8). Other ponds with moderately high turtle trapping success were gravel pit #58, and lake #60 (Tables 4 and 8).

4.1.8 Two-Striped Garter Snake

The two-striped garter snake was found in San Antonio Creek, Cañada Honda, and Jalama lagoon (Figure 13). The only pond in which this species was found is #74 (sighting by Jim Watkins, U.S. Fish and Wildlife Service,

personal communication). This species was most common in Cañada Honda. One reach in the middle section of Cañada Honda had a maximum count of 4 snakes, and another reach had 3 snakes (Table 4). All other sightings were single individuals per survey.

4.1.9 Coast Horned Lizard

The coast horned lizard was observed on the south slope of Burton Mesa near 13th Street, and in the vicinity of Pine Canyon Lakes (Figure 14). An isolated sighting occurred in the San Antonio Valley (Paul Collins, Santa Barbara Museum of Natural History, personal communication). The distribution of this taxon on VAFB is probably more extensive than revealed by 1995 surveys.

4.1.10 California Legless Lizard

The California legless lizard was recorded at two localities during 1995 field surveys, and this species may be more widespread. The lizard was found associated with stabilized dunes at San Antonio Terrace near Umbra Road and approximately 2 km north of the mouth of the Santa Ynez (Figure 15). In April 1996, a legless lizard was collected near Mod III pond (#39) (Mark Holmgren, University of California, Santa Barbara, personal communication). In 1987, legless lizards were found distributed throughout San Antonio Terrace, and among dunes from Shuman Creek to San Antonio Creek (collections of the Museum of Systematics and Ecology, University of California, Santa Barbara) (Appendix D).

4.2 Habitat Evaluation

4.2.1 Western Spadefoot Toad

Discriminant analysis indicated that the most important habitat variable that predicts presence of spadefoot toads is substrate composed mainly of sand (Figure 16). Toad pools were also slightly larger in surface area (Figure 17), and deeper (mean toad pool depth was 0.28 m and pools without toads had mean depth 0.18 m). Toad pools were less vegetated, with greater percentages of open water, and lower percentages of emergents (*Juncus* sp., *Carex* sp., herbaceous sp., and grasses) (Figure 18). Of the dominant types of pond vegetation, cover by iceplant (*Carpobrotus* sp.) and pampas grass (*Cortaderia* sp.) was slightly greater at pools that had spadefoot toads (Figure 18). Upland vegetation adjacent to toad pools had higher percent cover of iceplant and coastal sage scrub than did non-toad pools (Figure 19). Spadefoot toad pools had lower percent coverages of upland grasses and herbaceous species than did non-toad pools (Figure 19). Student's independent *t*-tests performed on the habitat variables showed no significant difference ($P > 0.7$) in any category due to large standard deviations.

4.2.2 Red-legged Frog

4.2.2.1 Adults

Discriminant analysis of red-legged frog habitat variables was performed on two subsets: ponds and streams. The most important factor separating red-legged ponds from ponds without red-legged frogs was water depth. Although near-shore depth (measured approximately 5 m from shore) didn't vary much between the two types of sites (Figure 20), sites with frogs had greater maximum depth ($P = 0.018$, Student's independent *t*-test) (Figure 21). Other important habitat variables included a higher percentage of bank

and upland vegetation composed of emergents (rushes and sedges) and eucalyptus, while frogs ponds were negatively associated with chaparral and coastal sage scrub. Aquatic vegetation in ponds with red-legged frogs was composed of a greater percentage of submergents ($P = 0.048$, Student's independent t -test) and floating species (aquatic buttercup, *Hydrocotyl* sp., duckweed, *Lemna* sp., and water fern, *Azolla* sp.) (Figure 22).

In streams, the most important predictor of red-legged frog presence was water depth. Student's independent t -test showed the mean water depth at reaches of streams with red-legged frogs (0.45 m) to be greater ($P = 0.001$) than mean water depth at reaches of streams without red-legged frogs (0.15 m) (Figure 23). Reflecting this difference, substrate was usually of the smaller size categories at red-legged frog reaches. Mean stream width was greater for reaches with frogs than without frogs (Figure 24), and this was influenced by frogs present at every lagoon on the Base. Mean cover of aquatic vegetation at stream reaches with red-legged frogs had a slightly higher percentage of algae, submergent macrophytes, cattails (*Typha* sp.), tules (*Scirpus* sp.), and floating vegetation (Figure 25). Discriminant analysis on bank vegetation types found the greatest degree of importance for percent of bank covered by understory spreading species, such as stinging nettle (*Urtica* sp.), poison oak (*Toxicodendron diversiloba*), blackberry (*Rubus* sp.) and others. This vegetation type was greater for reaches without frogs ($P = 0.04$, Student's independent t -test) (Figure 26). Discriminant analysis also showed that sites with frogs were correlated with high cover of herbaceous plants and emergent species, such as rushes, sedges, (Figure 26), cattails and tules. Willow species (*Salix* sp.) did not respond as expected; there was a lower percentage of cover by aquatic willows (inundated) and bank willows at reaches with frogs (Figures 25 and 26).

4.2.2.2 Pre-Adult Stages

Red-legged frog egg masses were found attached near the surface of the water to willow branches, tules and cattails. In most cases, the vegetation used occurred in dense stands (Figure 27). In areas with fluctuating water levels, some egg masses were found completely or partially stranded out of water (personal observation).

Due to wide environmental variation within and between sites sampled for red-legged frog tadpoles, there was no clear relationship in abundance of tadpoles to the habitat variables measured. Three out of four of the samples with the greatest numbers of tadpoles were from sites with high densities of floating (aquatic buttercup, duckweed and water fern) and submergent (algae and macrophytic) vegetation types (Figure 28). Water temperature was noticeably higher in areas with floating and submergent vegetation than in open water situations (personal observation). There was little correlation between the absence of aquatic vegetation and the number of tadpoles trapped (Figure 29).

Metamorph red-legged frogs showed less discrimination for microhabitat selection than did adults (personal observation). In several instances, they were found at sites with maximum water depth as low as 0.1 m. They often used bank habitat with less vegetative cover than did adult red-legged frogs (personal observation).

4.2.2.3 Streams vs. Ponds for Red-legged Frog Reproduction

Mean total length and mean length of hind legs were significantly greater ($P < 0.001$) at pond #27 than at Jalama lagoon (Figures 30 and 31). The tadpoles measured from other ponds appear to be similar to those sampled at pond #27, and the Antonio lagoon tadpole was similar in size to those found

at Jalama lagoon. Measurements of Shuman lagoon tadpoles were similar to those at pond sites. Since peak flows are substantially greater for San Antonio Creek and Jalama Creek than for Shuman Creek (Coulombe and Cooper 1976), it is possible that March storms did not impact red-legged frog larval stages equivalently among these three stream sites. In late July, metamorphs were present only at pond #27, and tadpoles observed at stream sites were not close to transformation. The small standard errors suggest that successful spawning occurred within a narrow time frame at each site.

4.2.2.4 Co-occurrence with Introduced Predators

Red-legged frogs were present at 40 of 42 (95%) sites that were surveyed and appeared suitable based on habitat (permanent or near-permanent ponds and deep stream pools) (Figure 32). Of the sites from which red-legged frogs were absent, one site (#45) had introduced fishes (centrarchids and ictalurids) and bullfrogs. The other site was Cañada del Jolloru, which is heavily affected by livestock. Of the 40 sites which had adult red-legged frogs, 11 (28%) of these also had bullfrogs and 6 (15%) also had introduced fishes. All of the sites which had introduced fishes and red-legged frogs also had bullfrogs. Thus, every site with introduced fishes also had bullfrogs, but not every bullfrog site had introduced fishes.

Pre-adult (eggs, tadpoles, or metamorphs) red-legged frogs were found at 14 (54%) of the 26 "red-legged only" sites, whereas pre-adults were found at 3 (27%) of the 5 "red-legged and bullfrog" sites (Figure 32). Numbers of red-legged frog tadpoles (Figure 33) and metamorphs (Figure 34) were much higher at sites lacking bullfrogs than those with bullfrogs. There was only 1 site (2.5%) of the 6 "red-legged and introduced fish" sites which had pre-adult

red-legged frogs (Figure 32). Egg masses were found at this site, but numerous subsequent attempts failed to show any tadpoles or metamorphs.

4.2.3 Western Pond Turtle

Western pond turtles were found in ponds that had mean water depth greater than ponds in which they were absent ($P = 0.08$ Student's independent *t*-test) (Figure 35). The only type of aquatic vegetation that was correlated with the presence of turtles at pond sites was cattails and tules ($P = 0.07$, Student's independent *t*-test) (Figure 36). The presence of this type of vegetation may be important for pond turtles because dense clumps of bent-over reeds and floating mats of dead reeds are used as basking sites. Stream sites showed a similar relationship, but mean water depth was only slightly deeper at reaches with turtles than reaches without turtles (Figure 37). The most common basking site seen used by western pond turtles at stream sites was dense mats of filamentous green algae. On average, stream reaches with turtles had more algae (Figure 38).

4.2.4 Two-striped Garter Snake

Two-striped garter snakes were found only at stream sites, with the exception of the sighting at pond #74, which was not confirmed by the author. Two-striped garter snake abundance appears to be related to availability of prey. In Cañada Honda, Pacific chorus frog tadpoles occurred in high densities, and garter snakes were often observed in pools pursuing tadpoles. The two-striped garter snake at Jalama lagoon was also found in an area with high densities of red-legged frog, western toad, and Pacific chorus frog tadpoles. At San Antonio Creek, garter snakes may be more dependent on fish prey due to relative scarcity of tadpoles.

5.0 DISCUSSION

5.1 Status of the Western Spadefoot Toad

The Cantonment Area, which had the highest densities of western spadefoot toads, is unfortunately the region most likely to have human-caused disturbance. Construction of buildings and roads have apparently considerably decreased available breeding pool and upland refuge habitats. If development expands southeast of the present cluster of buildings, critical habitat will be impacted. Spadefoot toads were found to suffer mortality due to vehicular traffic on New Mexico Avenue. Although this area seems to receive light traffic during the toads' nocturnal activity period, Security Police were seen to patrol New Mexico Avenue more than once an hour throughout the night. Mowing occurs throughout the Cantonment Area throughout the spring, and may crush surface-active toads and those in shallow burrows. However, mowing may benefit spadefoot toad populations by maintaining low vegetative cover.

Other human-caused impacts in the Cantonment Area include alteration of habitat by earth-moving activities. Many areas have been ditched, and I suspect this resulted in draining vernal pools. Area #18 was apparently at one time an extensive network of vernal wetlands with pools interspersed. A large area (approximately 146 X 78 m) was bulldozed and created a deeper, lesser vegetated pool than was present previously (Figure 6). This disturbed site had the highest numbers of adult spadefoot toads and tadpoles. It is unclear if the habitat alteration favored spadefoot toads, or if the number found was a mere fraction of what it was before the disturbance. Two ways in which this disturbance may have benefited the species are:

- 1) creation of habitat which retains water longer into the spring than surrounding ponds, thereby increasing the potential success of larvae, and
- 2) creation of a sparsely vegetated shore with loose sand for burrowing, especially since substantial areas nearby have become thickly overgrown with iceplant (*Carpobrotus* sp.).

Populations of spadefoot toads found near Tangair Road (#34) and on San Antonio Terrace (El Rancho Road collection) are currently threatened by mortality due to vehicular traffic. Site #34 is the largest vernal pool observed on VAFB (Figure 7), but has been bisected by Tangair Road. It is also in close proximity to the airfield. Spadefoot toads may be more extensive on San Antonio Terrace than reported here. Human (1990) observed calling spadefoot toads in ponds #29 and #63, but these were not confirmed by sightings. Pacific chorus frogs occasionally have a call that is very similar to and may be mistaken for spadefoot calls (Sam Sweet, University of California, Santa Barbara, personal communication; personal observation).

Dune swale ponds used by spadefoot toads which are not located near roads, such as pond #59, are probably threatened mainly by iceplant invasion (Figure 8). Data indicate that spadefoot breeding pools are in the process of being invaded by iceplant (Figures 18 and 19). Iceplant negatively effects upland habitat quality for spadefoot toads by reducing the amount of bare sand (see Stebbins 1985). In addition, ponds with a substantial area of inundated iceplant were odoriferous from decaying plant matter and anaerobic conditions, had dark-stained murky water, and had lower diversity and abundance of invertebrates and amphibians (personal observation). Four vernal pools (#28, #52, #53, and #65) that appeared visually to have the most rotting iceplant but were seemingly otherwise suitable for spadefoot toads

(due to depth and geographic proximity to other spadefoot sites), did not have spadefoot toads (personal observation).

5.2 Status of the Red-Legged Frog

The lower drainage basin of San Antonio Creek and the adjacent San Antonio Terrace are likely to be one of the most productive areas for red-legged frogs in Santa Barbara County (personal observation). While localities within this region have experienced modifications which are suspected to cause declines in other areas (such as introduction of predators, decreased wetland habitat due to excessive groundwater use, flooding, etc.), there is a relative abundance of adjacent sites which are free from these impacts and may in fact be locations of source populations. In particular, most dune swale ponds have remained essentially undisturbed, except for some loss due to road construction. These ponds, which may dry completely in drought years, are not suitable for introduced fishes, crayfish, and bullfrogs, but provide excellent habitat for red-legged frogs. Eucalyptus ponds #63 and #73 may be too well-shaded and hence too cold for bullfrogs, or it is possible that bullfrogs are intolerant to chemicals leached from leaves to which red-legged frogs are not susceptible. San Antonio lagoon also represents excellent red-legged frog habitat.

The most apparent threat to red-legged frogs in San Antonio Creek is alteration of habitat related to agricultural activities in the upper portion of the drainage basin. Groundwater withdrawals which have depleted freshwater marsh habitat in Barka Slough are an obvious threat. Runoff of agricultural chemicals (Coulombe and Cooper 1976) poses a hazard, as does the runoff of substantial amounts of silt, which may fill in pools. Flooding in 1995 resulted in considerable bank erosion. Predatory fishes, bullfrogs,

crayfish, and predation and habitat alteration by feral pigs may negatively impact the red-legged frog. The presence of beaver may benefit red-legged frog populations through habitat enhancement.

Shuman Creek, due to close proximity to San Antonio Terrace, also probably receives a substantial number of emigrating frogs. The lagoon habitat appeared to be free of impacts generated on Base, however, contaminated water originating from the Casmalia Resources toxic waste site may threaten these amphibians. Just outside the Base boundary, a small population of red-legged frogs was present at several deep pools. This area is used as a dumping site for household trash, and the presence of oil, paint and solvents is of concern. Steep slopes and erodible soil, combined with livestock grazing and cultivation, have resulted in severe erosion near Point Sal Road (Butterworth 1988). Cattle grazing occurs on the terrace above the stream just east of the Base boundary, but the eroded banks are mostly too steep to permit cattle into the stream.

In comparison, red-legged frogs in the lower Santa Ynez River drainage basin have smaller population sizes, and they are more patchily distributed. Except for pond #81 and southern pond #30, the ponds in this region are not as deep or well-vegetated as those in the San Antonio watershed. In the lower Santa Ynez River, deep pools with dense marginal vegetation are rare, and introduced aquatic predators are abundant and diverse (see discussion below). Additional threats to red-legged frogs in the Santa Ynez River may be clearing vegetation and homogenizing the stream bed for flood control (Hunt 1990, Santa Barbara County Flood Control & Water Conservation District 1990), and water quality problems due to agricultural and urban runoff and sewage effluent (Coulombe and Cooper 1976). Growth of willow and emergent vegetation should be enhanced at ponds in the lower Santa Ynez

Valley (such as created duck ponds #48) to discourage establishment of bullfrogs and provide better habitat for red-legged frogs.

Cañada Honda has received relatively little anthropogenic disturbance. Cattle grazing and naturally erodible soils (Butterworth 1988) have resulted in stream incision and steep banks throughout the drainage. Cattle are currently impacting the main channel outside the Base boundary (Figure 39), and at tributaries near Tranquillon Mountain Road on the Base, but have been fenced out of the rest of the creek. Erosion of stream banks may pose a problem for persistence of red-legged frogs since steep slopes may impede movement out of the stream channel during flooding (Figure 40). However, this has not been tested, and red-legged frogs have been observed perched 1 meter above water on verticle banks (personal observation). Channel morphology changes (such as deposition of eroded material or scour) which result in elimination of stream pools degrade habitat for red-legged frogs, as was observed in the area near the crossing of Coast Road (Figure 10). Thus, areas which are protected from cattle grazing by fencing may experience degradation of habitat due to deposition of material eroded from unprotected areas.

Jalama lagoon has a relatively large population of red-legged frogs. A potential impact to this species is from direct disturbance by visitors to Jalama Beach County Park. Nocturnal adult frogs are probably at less of a risk than are metamorphs, which are active during the day. Children were observed collecting >40 western toad and Pacific chorus frog metamorphs at a time. Park rangers reported finding visitors with amphibians and reptiles at campsites, and some probably remove them from the area.

The areas on VAFB with the most isolated populations of red-legged frogs appear to be the innominate "near Pt. Sal" stream, and cattle lake #87.

At the stream site, only one individual was observed, and the extent of potential habitat was not large. Pond #87 was completely devoid of bank vegetation due to trampling by cattle (Figure 41), and red-legged metamorphs resorted to using hoofprints for cover. Fortunately, in response to recommendations resulting from the present study, VAFB has already undertaken habitat enhancement of this pond. Fencing to exclude cattle has been installed and cattail plugs will be planted (Allan Naydol, VAFB Chief of Natural Resources, personal communication).

Unseasonably heavy rains in March 1995 appear to have effected red-legged frog breeding activities. During flooding, egg masses and tadpoles may be washed out of streams. In San Antonio Creek, egg masses laid near the surface of the water were flagged before the flood. During high, swift-moving water egg masses were at least 0.5 m below the surface of the water. When the water level receded, however, a few of the same egg masses were found surprisingly intact. More significant mortality due to increased currents may have been incurred by newly-hatched red-legged frogs. Even though San Antonio Creek didn't receive scouring flows that were observed in lower Cañada Honda, the frogs appear to be adapted to late-season storms by extending their period of breeding activity. Calling males were heard until mid-April in San Antonio Creek, but breeding was probably completed before March in ponds lacking flow.

Red-legged frog tadpoles differed in developmental stage between pond and stream sites at a given time. If flooding was not a factor, we could assume that these sites differed in food availability, temperature, presence of competitors, or presence of predators which would alter tadpole behavior (i.e. decrease feeding activity by spending more time in refuge sites). While these factors may have acted upon the observed size differences, the possibility of

flood effects and consequential late-season breeding in streams are likely to have played a large part.

5.2.1 Co-occurrence With Bullfrogs

Most evidence of the impacts of bullfrogs on native frog species is correlational: as bullfrog populations expanded, native anuran populations were observed to decline or disappear, or within a given region, native frogs and bullfrogs do not co-occur (Dumas 1966, Licht 1973, Moyle 1973, Bury and Luckenbach 1976, Green 1978, Vitt and Ohmart 1978, Hammerson 1982, Hayes and Jennings 1988, Kupferberg 1993, Leonard et al. 1993). Evidence of predation by adult bullfrogs on other frogs and tadpoles is well documented (Storer 1922, Frost 1935, Cohen and Howard 1958, Stewart and Sandison 1972, Moyle 1973, Licht 1973, Walters 1975, Cecil and Just 1979, Corse and Metter 1980, Hammerson 1982, Stumpel 1992, Leonard et al. 1993). Tadpoles of bullfrogs are also found to prey upon eggs and newly-hatched anuran larvae (Ehrlich 1979).

Competition effects between anurans may take two possible pathways. Competitors may coexist at densities lower than they would achieve by themselves. This interaction is based on the ability of the competitors to partition their resources or habitats, thereby narrowing their niche and increasing intraspecific competition (Wiens 1977, Connell 1983). The alternative is that a superior competitor eliminates the other species (Inger and Greenberg 1966). This is commonly the case with invasions of exotic species. When resource availability is high, the exotic species is able to invade. However, when environmental conditions become severe, a "bottleneck" occurs. The species which will dominate in the future will have the greatest rate of expansion due to ability to establish a breeding population

from a small number of individuals (high fecundity and high larval survival), and will be able to do well under a wide range of changing conditions (Wiens 1977).

It has been suggested that bullfrogs and red-legged frogs have similar ecological requirements (Storer 1925, Moyle 1973), thus significant resource partitioning may not occur. Although red-legged frogs breed earlier in the year and have a greater growth rate (Storer 1925, Dumas 1966, Licht 1971), newly-hatched red-legged larvae must contend with bullfrog tadpoles which have overwintered and may be 10 times larger (see Bury and Whelan 1984). In tadpole competition experiments performed in enclosures on the Eel River, California, bullfrogs were found to cause a 48% reduction in survivorship and a 24% reduction in mass at metamorphosis for the native foothill yellow legged frog, and a 16% reduction in mass but no change in survival for Pacific chorus frogs (Kupferberg 1993). Adult red-legged frogs and bullfrogs share many of the same prey, and may compete for food resources (Frost 1935, Cohen and Howard 1958, Stewart and Sandison 1972, Mahon and Aiken 1977, Corse and Metter 1980, Hayes and Tennant 1985, Hayes and Warner 1985, Licht 1986) and refuge sites.

5.2.2 Co-occurrence With Non-native Fish Species

There is a significant amount of correlational evidence that fish introductions and transfers of native species have resulted in the disappearance of anurans from a number of areas. The best examples are the formerly fishless lakes of the Sierra Nevada, where trout introductions have been conducted since the late 19th century (Moyle 1976). Areas in the Sierra Nevada that contain introduced fishes have few or no ranid frogs (Cory 1963, Bradford 1989, Bradford et al. 1993).

The distribution of fishes and red-legged frogs show a trend similar to that of other anurans. Hayes and Jennings (1986) found low co-occurrence of introduced fish with red-legged frogs and the foothill yellow-legged frog. In addition, they concluded that the disappearance of these species from many areas coincided with the time of fish introductions. The red-legged frog is more often found to occur with native fishes than with introduced fishes (Hayes and Jennings 1988). Co-occurrence with native fishes is thought to be possible since native fishes are visual feeders and obtain their prey from the water column. If tadpoles have adequate refuge in vegetation or in the benthos, this type of predation is unlikely to have a major effect on amphibian populations (Hayes and Jennings 1986). In contrast, benthos feeding ictalurids and centrarchids may have a dramatic effect on anuran larvae (Hayes and Jennings 1986).

Of any tadpole predator, fish are found to be the most effective (Voris and Bacon 1966, Hayes and Jennings 1986, Semlitsch 1993), and are the only aquatic predator known to be capable of eliminating anurans from ponds (Heyer et al. 1975). Rates of fish predation on tadpoles increase during droughts and seasonal dry periods, when tadpoles and fish are confined to the same habitats (Moyle 1973, Jennings 1988). Anurans have responded evolutionarily to fish predation by modifying their choice of oviposition site, and through morphological and physiological egg protections (Grubb 1972, Brodie and Formanowicz 1987, Resetarits and Wilbur 1989). Eastern species of ranids are suggested to have larvae which are morphologically adapted for a mostly sessile life in the benthos (Peterson et al. 1992). Due to lack of such pressures evolutionarily, red-legged frogs probably do not have similar protections.

Bullfrogs tend to co-occur with introduced fishes (Moyle 1973, personal observation). It is thought that fish do not prey upon bullfrog tadpoles because they are unpalatable (Walters 1975, Krause and Francis 1977, Cecil and Just 1979), or too big (Heyer et al. 1975). Tadpoles of the bullfrog may be unavailable to predation through their use of microhabitat and degree of activity as they are known to remain buried in the leaves and sediments of streams bottoms (Heyer et al. 1975, Woodward 1983).

5.2.3 Confounding Effects of Habitat Complexity

Because many anthropogenic habitat alterations favor bullfrogs and introduced fishes, and are unfavorable to red-legged frogs (Moyle 1973), it is difficult to assess the most important mechanism responsible for observed distribution patterns (Hayes and Jennings 1986). It is unclear if the introduced species are favored because of the habitat, or if there are direct or indirect effects of the introduced species on red-legged frogs.

Availability of adjacent predator-free habitat may be critical for the maintenance of red-legged frog populations at sites with bullfrogs and introduced fishes. Coexistence may be explained by continual immigration of individuals too large to be preyed upon from predator-free sites. This phenomena may be occurring in the San Antonio Creek watershed. Where introduced predators co-occur with red-legged frogs, there was no to little red-legged frog reproduction. However, reproduction was high at adjacent predator-free sites, such as the dune swale ponds on San Antonio Terrace. Since western ranids often exist in small demes which are susceptible to extirpation and are thus dependent on immigration (Hayes and Jennings 1986), the ability to disperse is necessary for this species. Frogs seen on roads during rainy nights support the assumption that individuals make overland

movements. These dispersing frogs were > 70 mm snout-urostyle length, which may be larger than that which an average bullfrog would normally consume, and is beyond the size fish would consume. An interesting observation was that although Mod III (#39) has been stocked for recreational fishing in the past (Coulombe and Cooper 1976), stocking has not continued and red-legged frog reproduction was relatively high (Table 5).

5.3 Status of Western Pond Turtle

The most productive sites for western pond turtles are two of the largest impoundments on VAFB, Punchbowl and Pine Canyon Lakes. Unfortunately, both sites experience human disturbance due to sport fishing. One turtle trapped in Pine Canyon Lake had a notch in its upper jaw, apparently the result of a hook having been ripped out of its mouth. Another turtle was found entwined in fishing line in the willows. Turtles may spend a decreased amount of time basking due to human disturbances, especially by boats. Stocking introduced fishes is suspected to impact pond turtles (Moyle 1973, Jennings et al. 1992, Jennings and Hayes 1994a). Turtles moving between upland wintering sites and the lakes must cross roads at both Punchbowl and Pine Canyon Lakes. Fortunately, these roads receive low traffic, and no vehicle-caused mortality was observed.

The vicinity of San Antonio Creek, including associated drainages and ponds, is also a productive area for pond turtles. Turtles appear to benefit from the creation of beaver (*Castor canadensis*) ponds in San Antonio Creek. An irrigation pond (#83) just off VAFB was found to be used by western pond turtles, however, one individual was found entangled in abandoned twine at the water's edge. Roads that receive moderately high usage occur between potential western pond turtle overwintering sites, and San Antonio Creek

and associated ponds. Agriculture near Richmond Road may negatively impact this taxon by elimination of winter refuge and oviposition sites.

Jalama lagoon supports a relatively large population of western pond turtles. Many turtles can readily be seen from Jalama Beach County Park basking on the bank and algal mats. Visitors to the park frequently disturb the basking turtles by floating up to them on boats or surfboards, and occasionally catch them (personal observation).

Western pond turtle populations are probably not as large in Cañada Honda and Santa Ynez River as from the sites described above. Habitat is probably not as suitable, due to fewer deep pools. Only one area in Cañada Honda was found to have pond turtles, but I expect turtles to be present in other reaches of this stream (depending on the presence of pools) and at the lagoon. Due to the eroded nature of the stream channel, movement to overwintering sites may be difficult for western pond turtles at Cañada Honda. Eroded soil deposited in the stream may negatively impact pond turtles by decreasing available deep pool habitat. This year pond turtles were not found in lower Santa Ynez proper. Hunt (1990) observed them at the crossings of 13th Street and Floradale Road. Turtle trapping performed at 13th Street failed to produce turtles. Habitat just above the lagoon appeared suitable for pond turtles, and turtle trapping was attempted, but the traps could not be left in place for the normal duration due to access difficulties. Pond turtles can be expected to occur in the Santa Ynez River, especially if scour events result in better pools than were present in 1995.

5.4 Status of the Two-striped Garter Snake

Relatively large populations of two-striped garter snakes occur in Cañada Honda and San Antonio Creek. Garter snakes were more easily seen

during surveys at Cañada Honda, as they were visible in small clear pools. The perceived threats to these populations are generally the same as listed for pond turtles at these sites. Direct human disturbance at Jalama Beach, the erosive nature of Cañada Honda, and roads and agriculture in San Antonio Valley may negatively impact this taxon.

5.5 Impacts of Beaver and Feral Pigs

Beaver were observed in San Antonio Creek and associated drainages, and in the Santa Ynez River. Beaver dams drastically alter stream morphology and flow dynamics (Figures 44 and 45). In some cases (ponds #37 and #61), beaver dams have been maintained for at least two decades and thus have made relatively long-term alterations in habitat (Coulombe and Mahrtdt 1976, personal observation). Fortunately for red-legged frogs and western pond turtles, beaver activities may result in more good than harm. While it is true that riparian vegetation is removed by beaver, creation of deep, slow-moving water is critical for these sensitive species has possibly benefited their populations overall.

Feral pigs were observed in San Antonio Valley. Pig trails and accounts from hunters indicate that they are also present in Cañada Honda. Feral pigs tend to concentrate in riparian areas for most of the year (Pine and Gerdes 1973, Breiningner 1989). Pigs engage in rooting, wallowing, and tusking (rubbing their canine teeth against a tree, which may girdle it) which may significantly alter vegetative communities (Wood and Barrett 1979, Dial 1980, P. W. Collins 1990, Nee 1992). Feral pigs are omnivores; although most of their diet consists of plants, they may occasionally feed upon amphibians and reptiles (Wood and Barrett 1979, Nee 1992).

6.0 MANAGEMENT RECOMMENDATIONS

6.1 Spadefoot Toad Habitat Protection

The best protection for spadefoot toads on VAFB would require a complete restructuring of the Main Administrative (Cantonment) Area. Since this is probably not feasible, human activities must be carefully planned to minimize impacts. Construction of new buildings and roads should not occur within 0.3 km of potential breeding pools, including those which appear only in unusually wet years. New Mexico Avenue between 13th Street and 35th Street should be closed to vehicular traffic at night during potential spadefoot toad breeding migrations: during rain from January through March. Mowing after vernal pools have dried will minimize potential direct negative impacts. No new development or road building should occur within 0.5 km of Tangair Road and San Antonio Terrace breeding populations.

6.2 Grazing and Erosion Concerns

Grazing in the watershed of Cañada Honda has resulted in considerable erosion due to steep slopes and erodible soils (Figures 39 and 40). Below the crossing of San Miguelito Road near the eastern Base boundary, erosion is due to mainly natural causes (Butterworth 1988). However, upstream of the crossing and in the tributary near the junction of Tranquillon Mountain Road, Santa Ynez Ridge Road, and LaSalle Canyon Road, cattle currently impact stream banks directly. This should be prevented through fencing to decrease input of erosive materials into the stream system, which may fill in downstream pools.

Grazing has impacted wetland vegetation significantly in the ditched portion of lower San Miguelito and Lompoc Canyon Creeks, adjacent to

Ocean Avenue (Figure 42). Red-legged frogs and western pond turtles are found less than 0.2 km downstream of the impacted area, and a red-legged frog was found at a beaver dam in the ditch approximately 0.3 km upstream of this impacted area. Currently, between these two sites the water depth is not sufficient to maintain red-legged frogs. This may be due directly or indirectly to effects of cattle grazing. Fortunately, following recommendations provided from this study, VAFB has fenced off this area to exclude cattle. In addition, pond #87 which had heavy impacts from cattle has also subsequently been fenced (Nancy Read, VAFB Wildlife Biologist, personal communication).

Erosion in San Antonio Valley has been extensive, especially on lands east of VAFB. Most of the valley is under agriculture or livestock grazing, and riparian forest has been cleared up to the stream channel. When overland flow occurs on the exposed soil, a considerable amount of top soil is eroded into San Antonio Creek. This is evidenced by deposition at the crossing of Lompoc-Casmalia Road, where silt has accumulated enough to fill in the area under the bridge (Figure 43), and was deposited on the roadway up to 0.5 m deep (personal observation). Proposed actions are discussed below.

6.3 Lompoc-Casmalia Road Crossing of San Antonio Creek

Deposition of silt at the Lompoc-Casmalia Road crossing of San Antonio Creek was extensive during the 1995 storms, and has resulted in road closure through the fall (Figure 43). Proposals to repair the crossing include: 1) building an overpass over the existing crossing, 2) scraping the road surface and removing silt immediately at the bridge, and 3) bulldozing silt accumulated throughout the stream for a considerable distance away from the road crossing (Nancy Read, VAFB Wildlife Biologist, personal

communication). Due to the presence of red-legged frogs and western pond turtles at the pools on either side of the bridge, any disturbances to the stream channel itself (options 2 and 3 above) are not recommended. If the overpass could not be built, and it was deemed necessary to reopen the road, impacts to sensitive amphibians and reptiles could be minimized by removing silt adjacent to the road crossing from December and January, when most red-legged frogs and pond turtles are expected to be in upland sites.

6.4 San Antonio Watershed Management

Long-term solutions for erosion control, water quality protection, and assurance of minimum natural water levels in the San Antonio watershed should be implemented to protect palustrine areas and reduce future maintenance costs. This region likely provides the most critical habitat on VAFB for several species of amphibians and reptiles. While most of San Antonio Creek within VAFB boundaries is relatively protected, it is impacted by upstream and floodplain disturbances. Farming both on and off-Base increases the inputs of silt to San Antonio Creek during flood events, and results in decreased habitat suitability for red-legged frogs and western pond turtles when deep pools are filled by deposition of silt. This is particularly a problem in the off-Base areas in the drainage, where the riparian buffer has been removed. VAFB could decrease siltation resulting from farming on their lands by maintaining a wide riparian buffer and creating a berm at the lower field edges.

Irrigation of off-Base agricultural lands has overdrawn the aquifer which feeds Barka Slough. Reduction of aquifer usage and alternative water sources for agricultural irrigation should be addressed to protect this valuable habitat. Runoff in these irrigated fields should be contained and allowed to

percolate back into the groundwater. This should reduce the amount of agricultural chemicals that would otherwise run directly into San Antonio Creek.

6.5 Introduced Species Concerns

6.5.1 Iceplant

Planted as an ornamental, iceplant has successfully spread throughout VAFB and threatens plant communities on sandy soils (Schmalzer and Hinkle 1987). Measures to control iceplant on VAFB through burning and herbicide spraying have been investigated (EARTH TECH et al. 1995), and implementation is being continued (personal observation). Iceplant appears to decrease habitat quality for spadefoot toads by effecting water quality, but this should be investigated further. Iceplant negatively effects spadefoot habitat through increasing density of ground cover. Critical areas in and near spadefoot breeding pools should be identified, and iceplant removal work should be conducted in July-November, during the period of spadefoot inactivity.

6.5.2 Eucalyptus

Although chemicals from eucalyptus are known to be toxic to other aquatic organisms (Srivastava and Krishna 1990), surveys on VAFB have shown that red-legged frogs reproduce successfully in ponds occurring in dense stands of bluegum eucalyptus. In addition, Mark Jennings (National Biological Service, personal communication) found that red-legged frog tadpoles were insensitive to all except the most concentrated infusions of eucalyptus leaves. Since bark and limbs from eucalyptus frequently break off, this debris in a pond provides complex habitat structure with a high

frequency of red-legged frog refuge sites (Figure 11). It is not recommended at this time to control eucalyptus at pond sites #63 and #73.

6.5.3 Beaver

Beaver are suspected to alter stream habitats in a manner which apparently favors red-legged frogs and western pond turtles (Figures 44 and 45). However, these habitat alterations may also benefit bullfrogs. Until further evidence is generated, it is not recommended to control beaver populations on VAFB.

6.5.4 Feral Pigs

Feral pigs may detrimentally affect streambank habitat through removal of vegetation during rooting, and by creation of runs and wallows (Wood and Barrett 1979, Dial 1980, P. W. Collins 1990, Nee 1992). In addition, pigs are suspected predators of at least some sensitive species of amphibians and reptiles (Wood and Barrett 1979, Nee 1992). Hunting should be permitted (if not encouraged) throughout VAFB, and a trapping program should be implemented.

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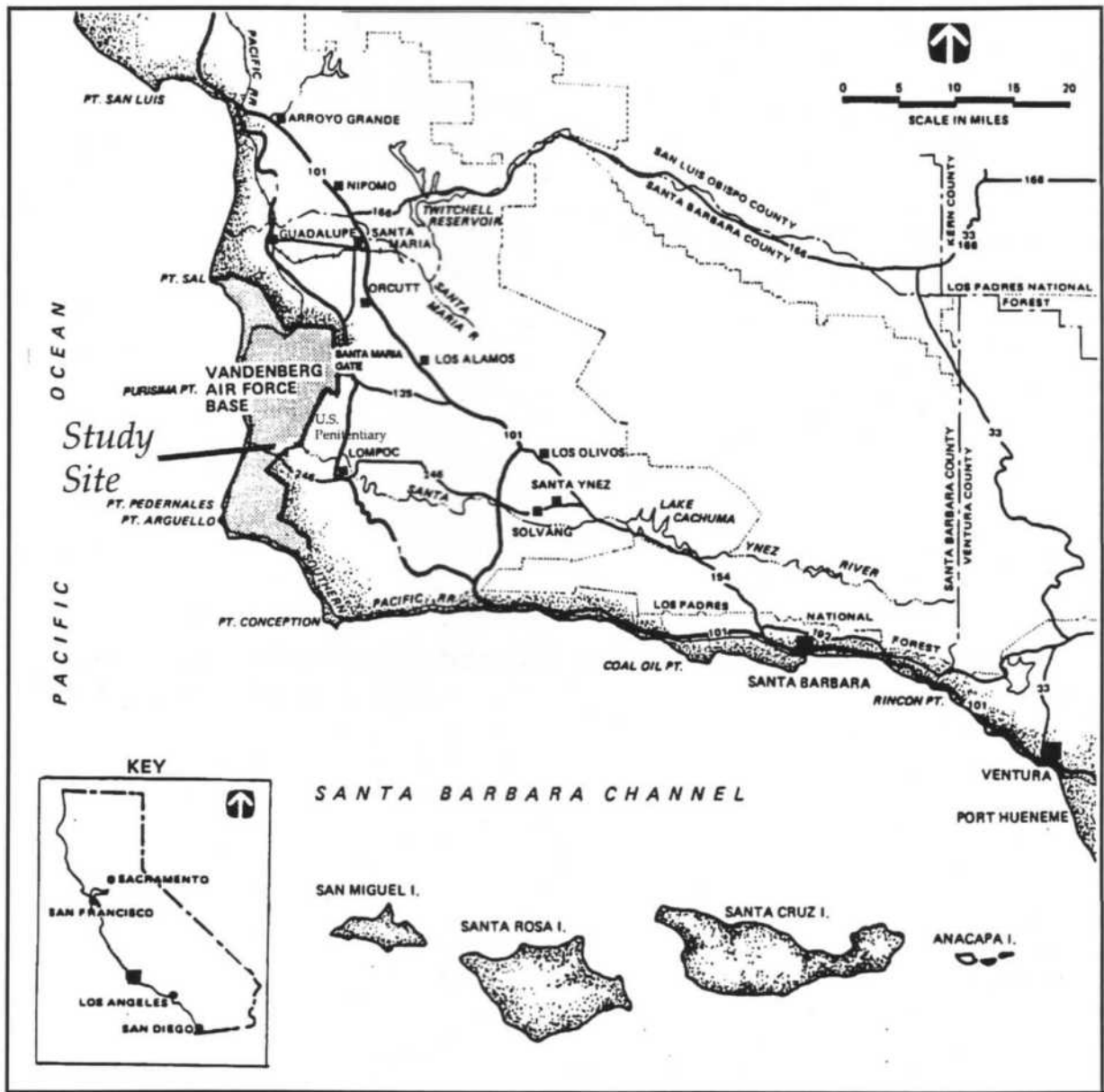


Figure 1. Area map of Santa Barbara County showing study site.

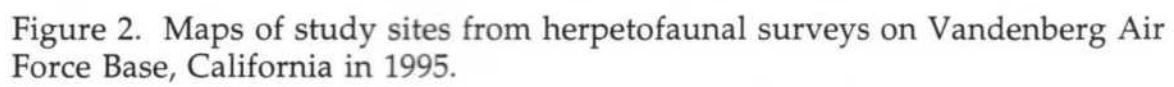
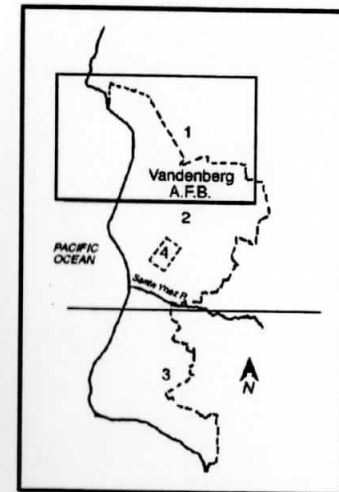


Figure 2. Maps of study sites from herpetofaunal surveys on Vandenberg Air Force Base, California in 1995.

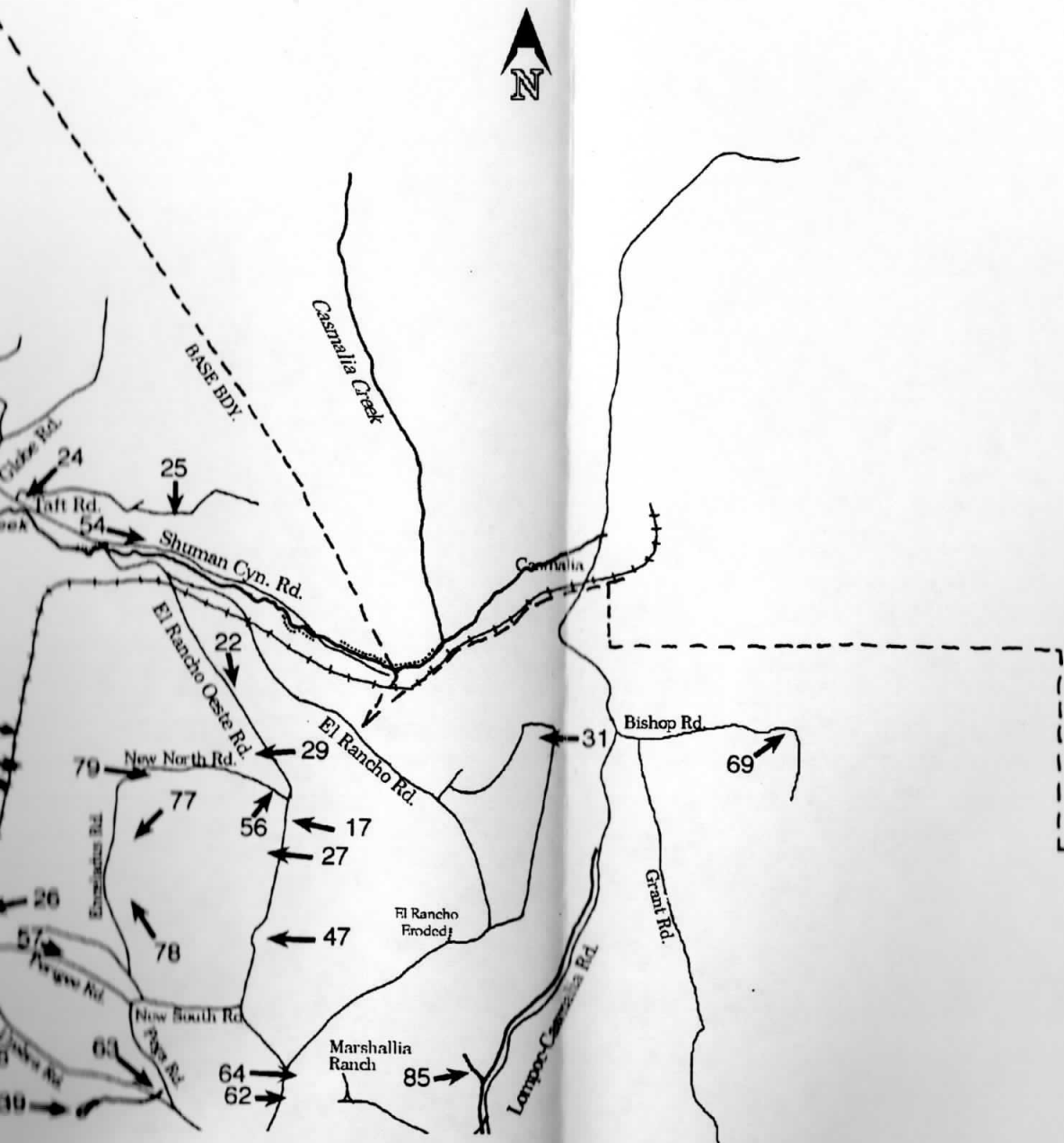
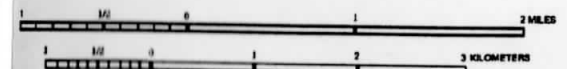
STUDY SITES AT VANDENBERG AIR FORCE BASE, CALIFORNIA 1995

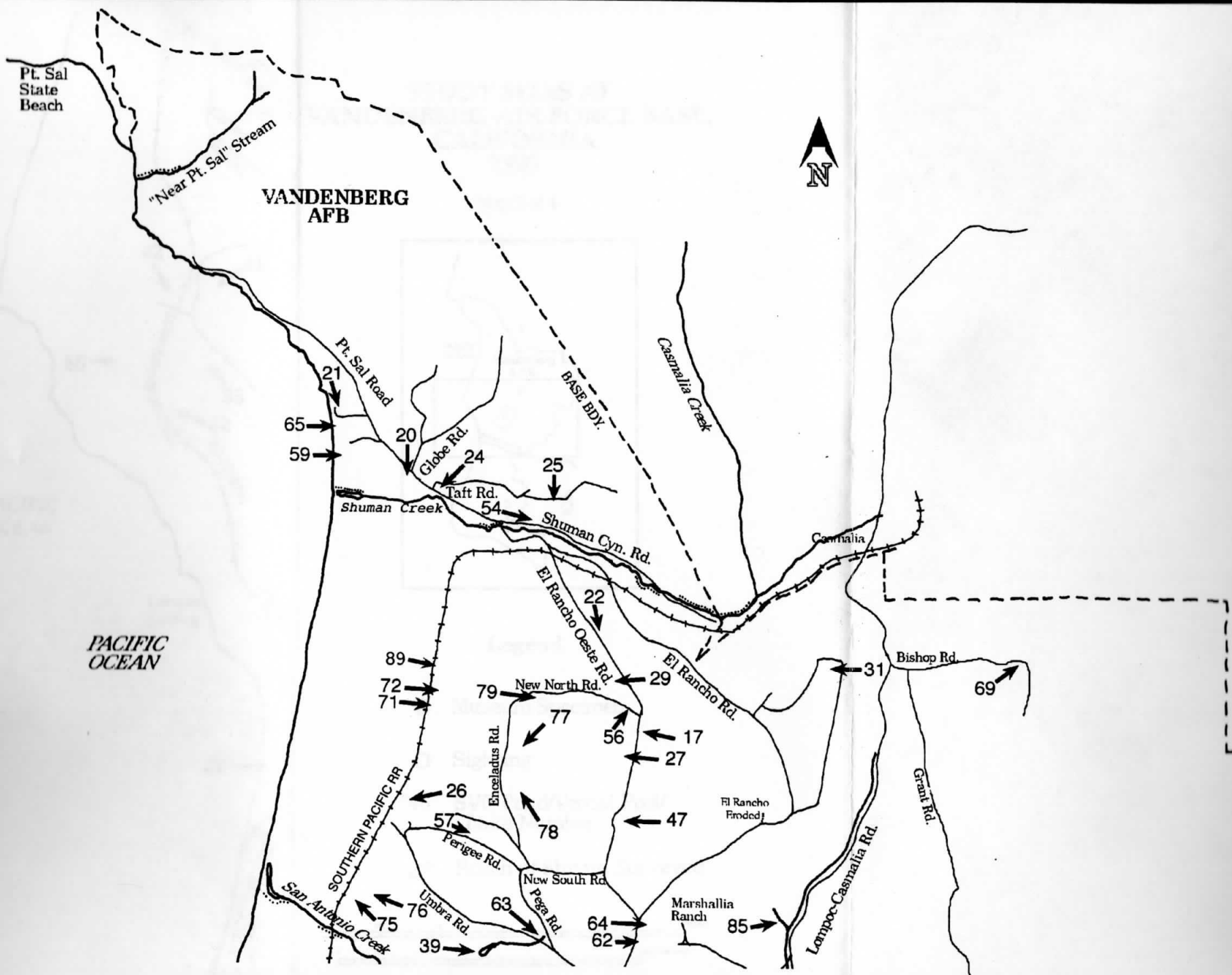
Map 1 of 4

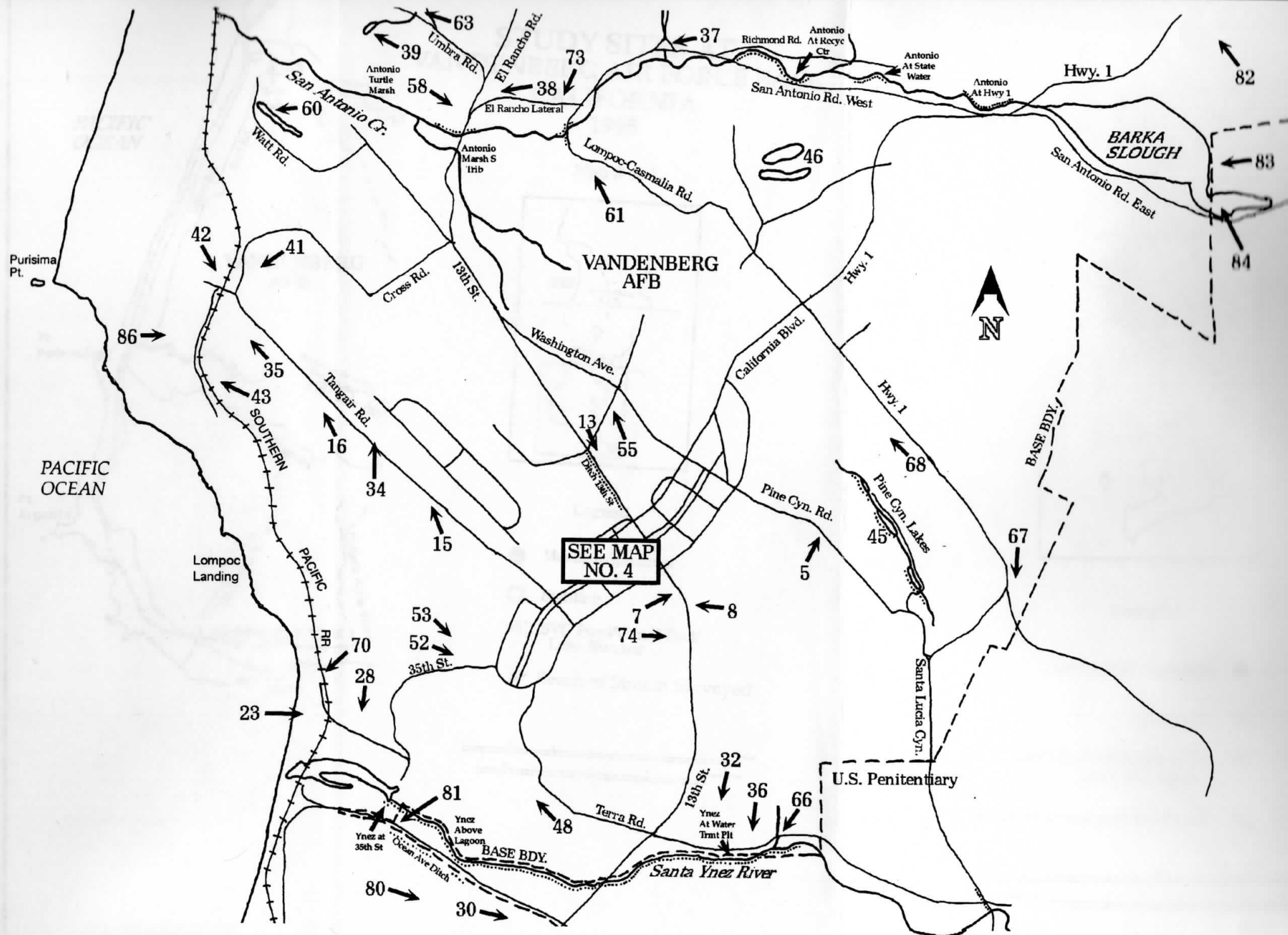


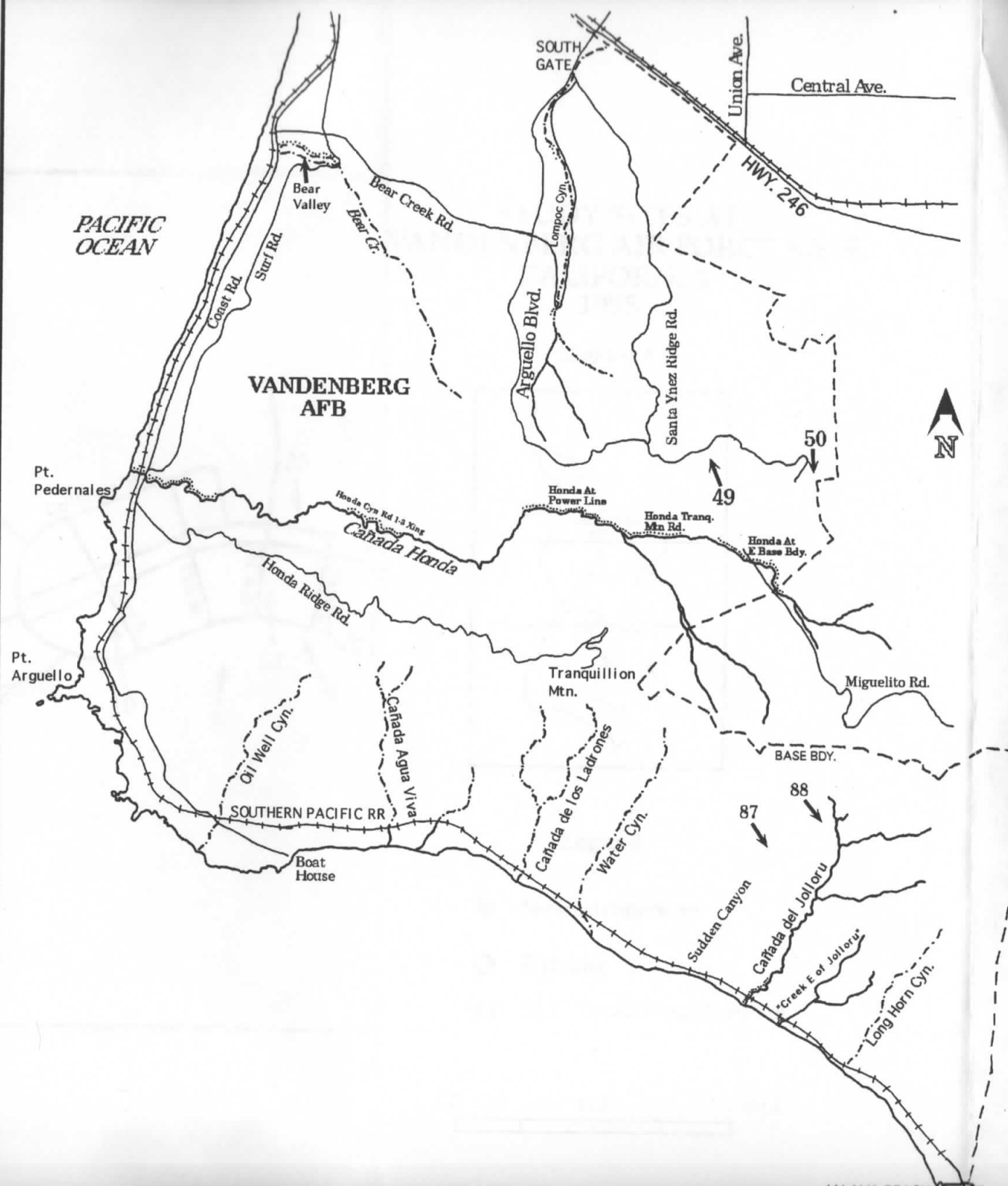
Legend

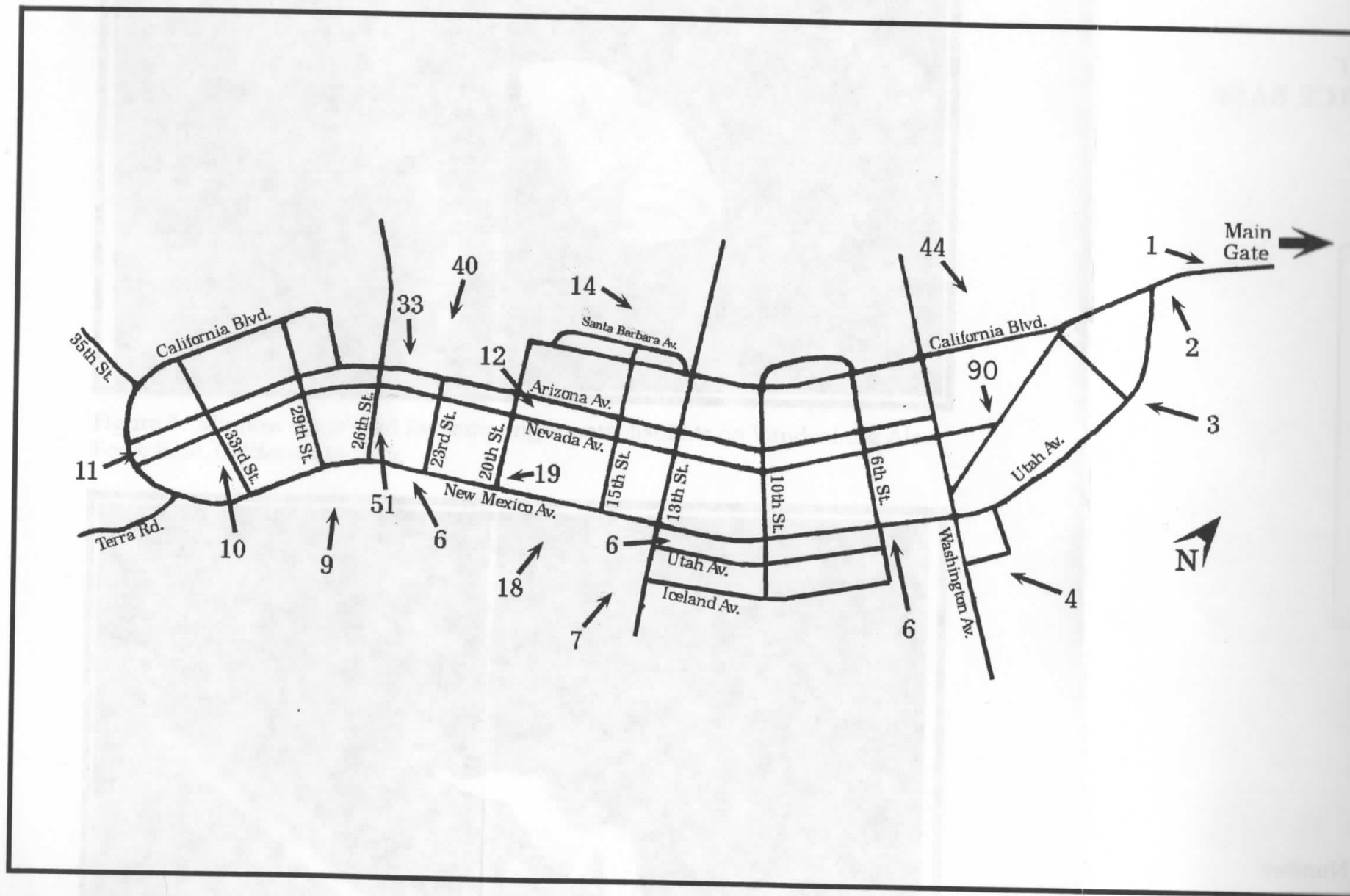
- Museum Specimen
- Sighting
- "46" SVC Pond/Vernal Pool/
Lake Number
- Reach of Stream Surveyed











Cantonment



Figure 3. Minnow traps used for sampling aquatic habitats on Vandenberg Air Force Base, California in 1995.



Figure 4. Turtle traps used for sampling aquatic habitats on Vandenberg Air Force Base, California in 1995.

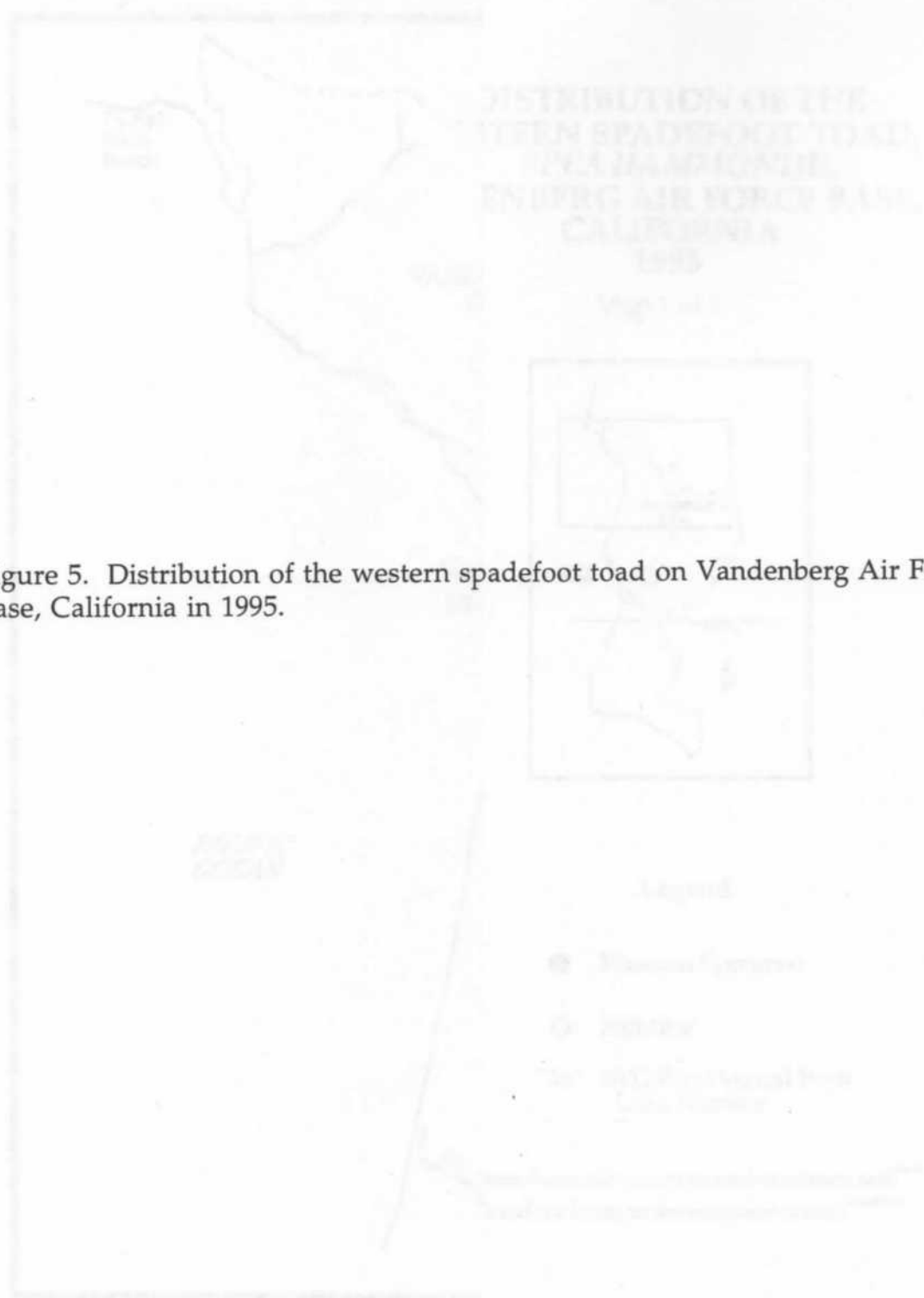
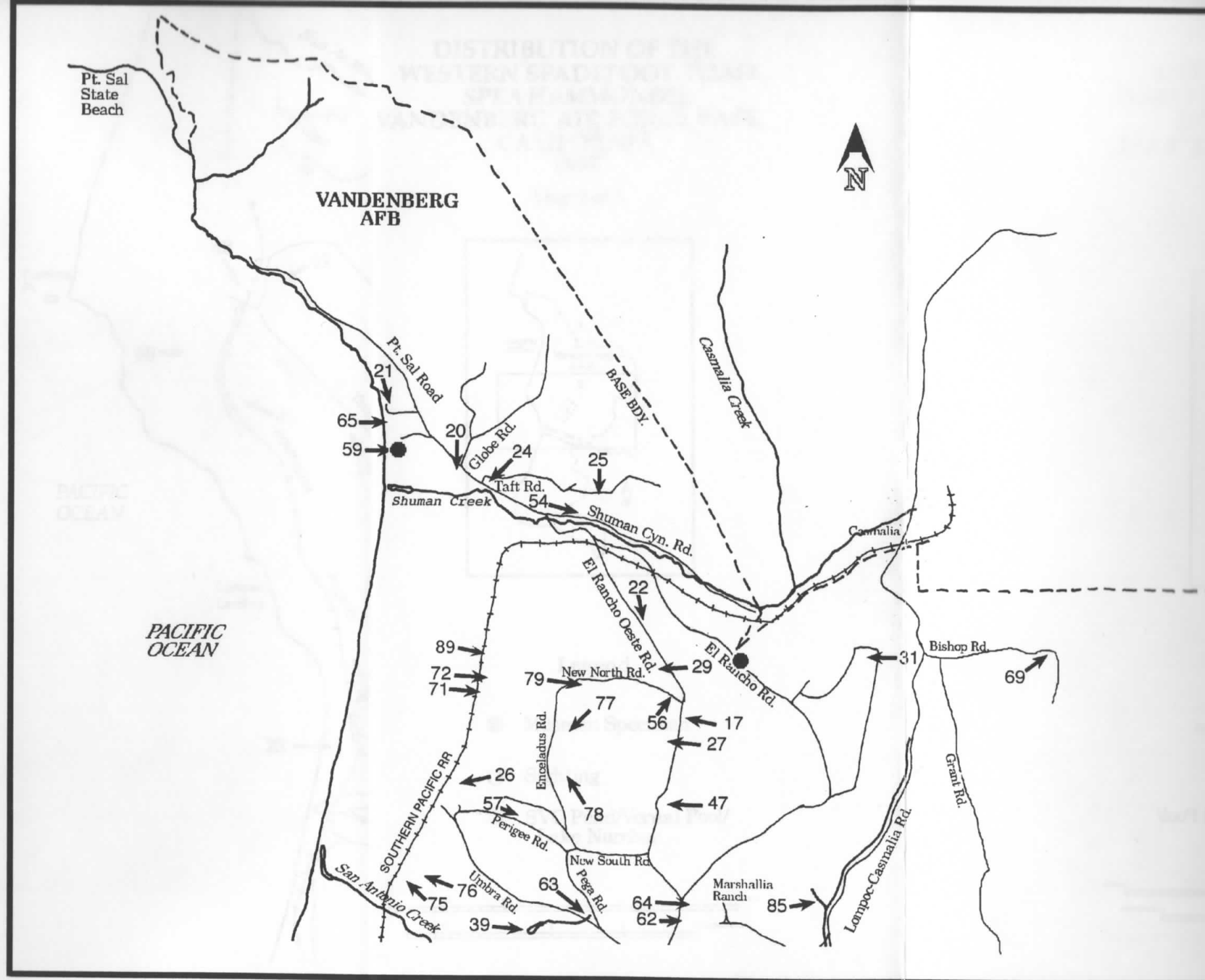
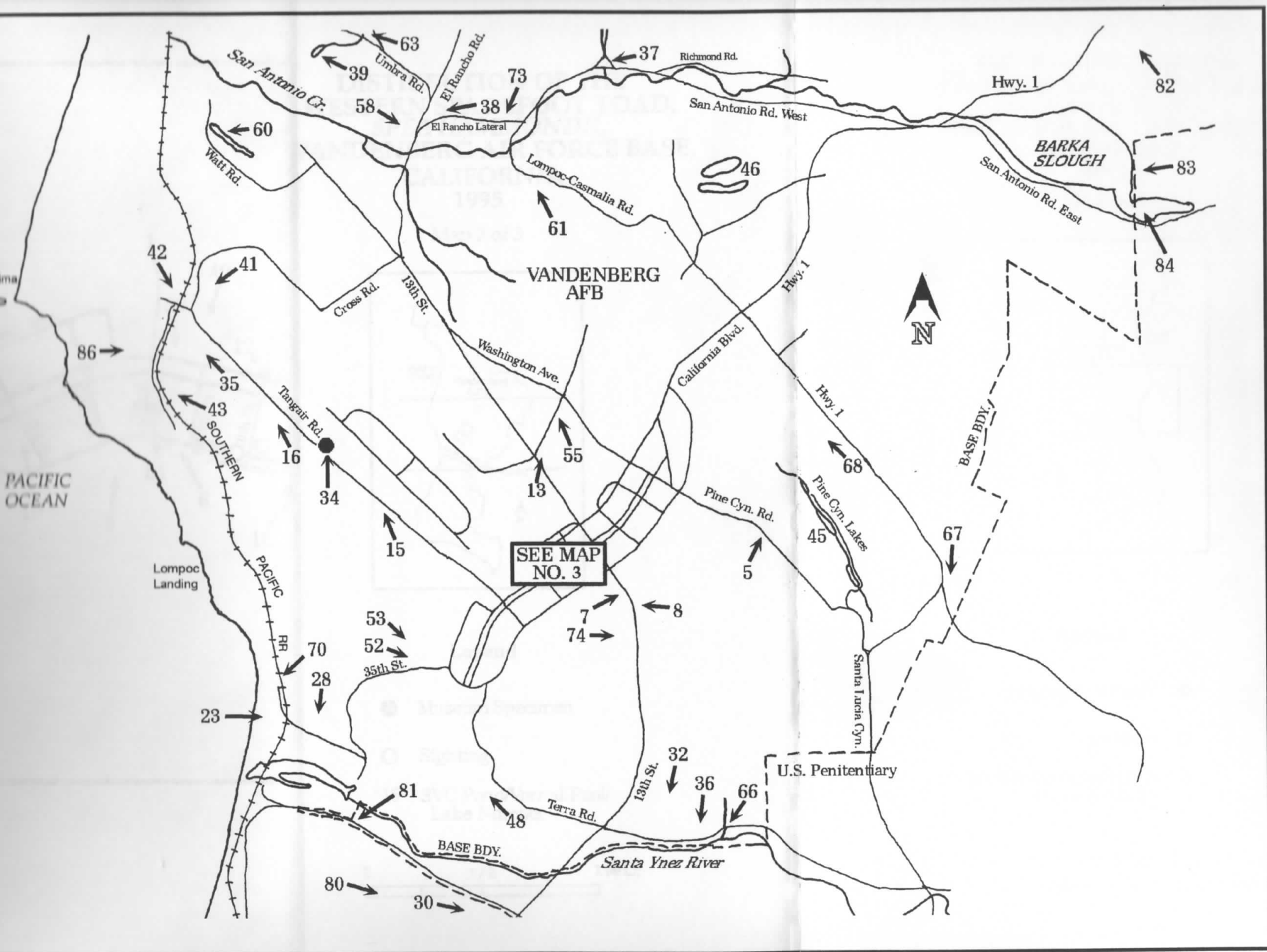
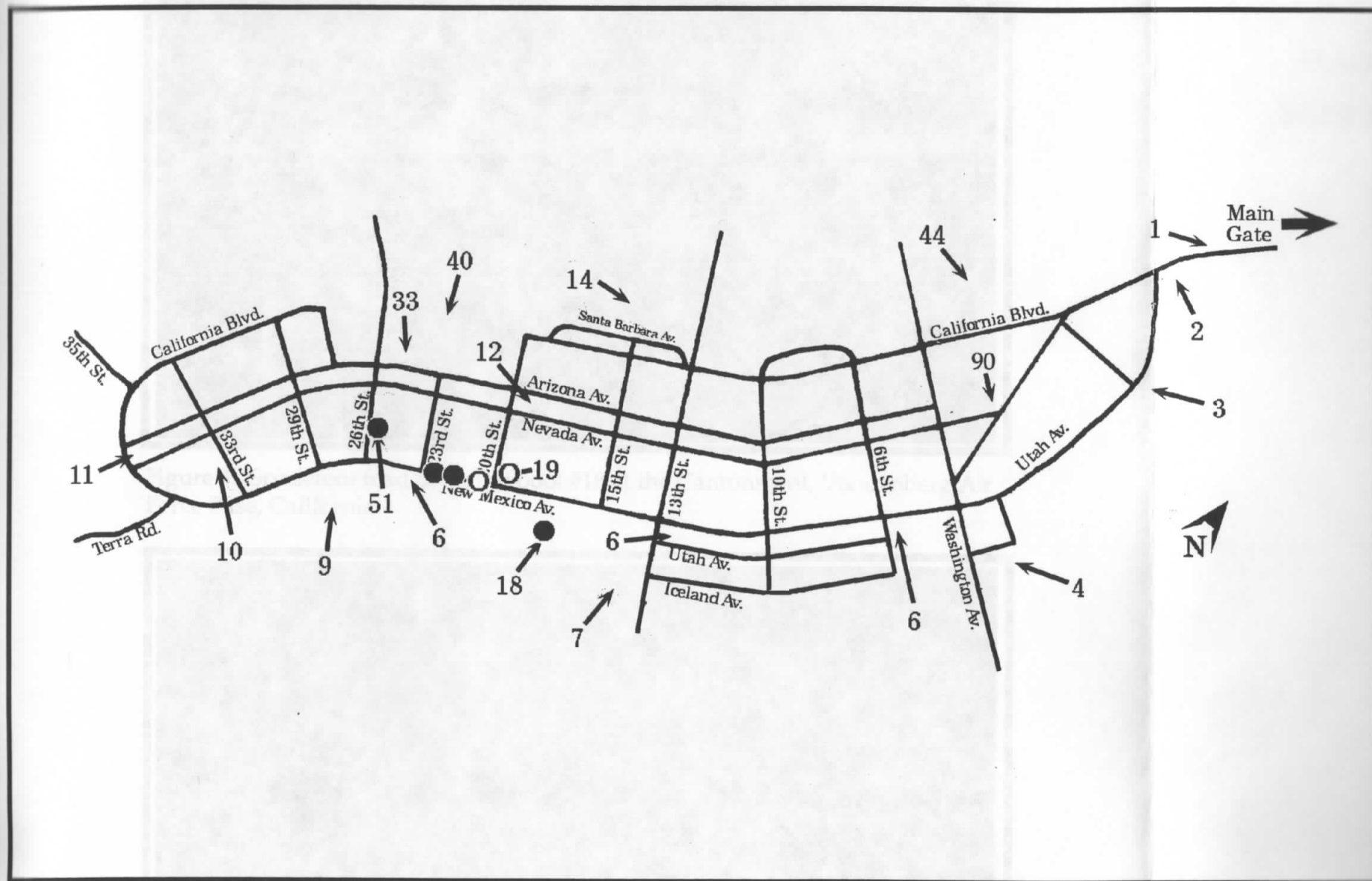


Figure 5. Distribution of the western spadefoot toad on Vandenberg Air Force Base, California in 1995.







Cantonment



Figure 6. Spadefoot toad breeding pool #18 at the Cantonment, Vandenberg Air Force Base, California.



Figure 7. Spadefoot toad breeding pool #34 at Tangair Road, Vandenberg Air Force Base, California.



Figure 8. Spadefoot toad breeding pool #59 south of Minuteman Beach, Vandenberg Air Force Base, California.

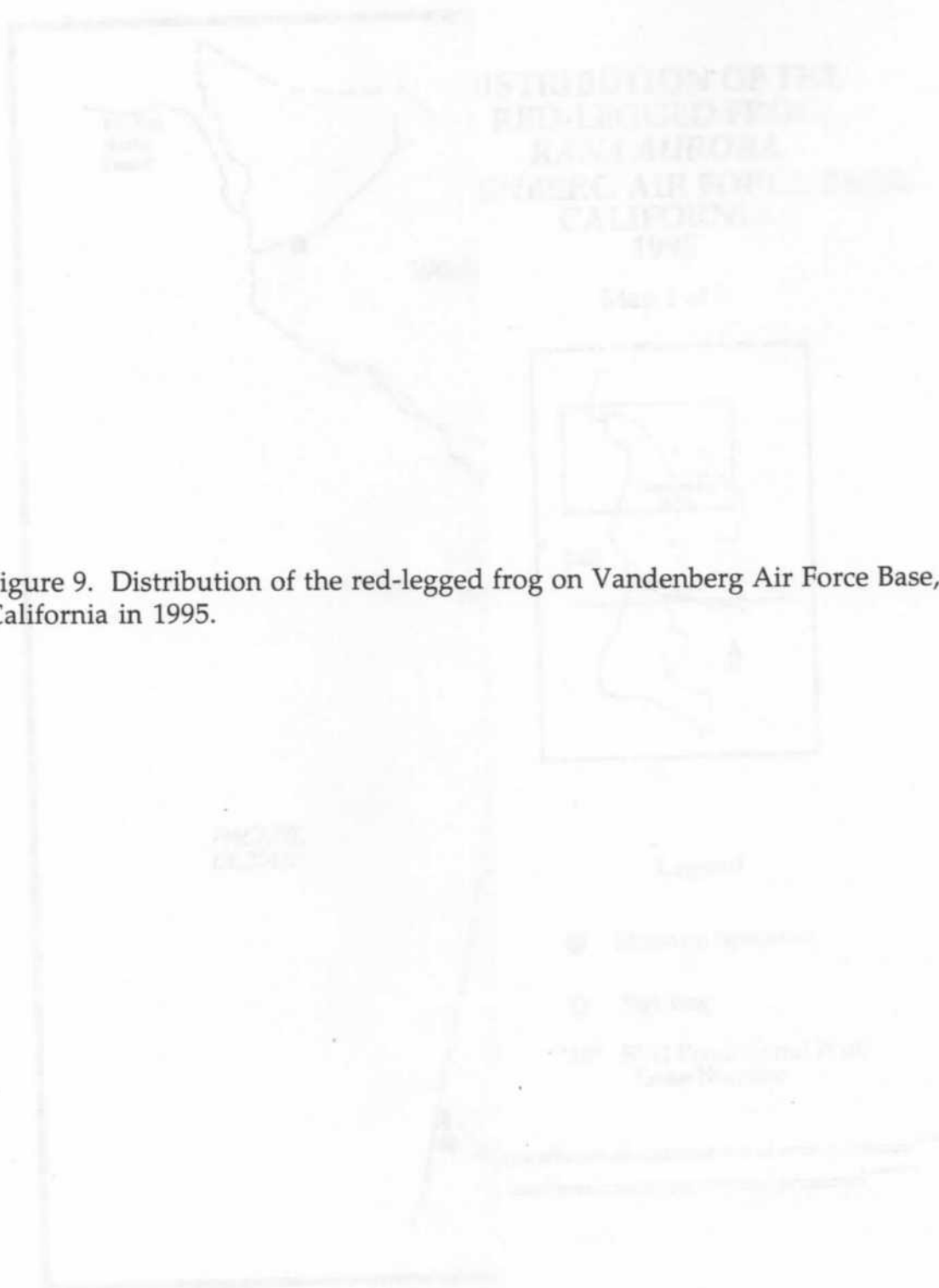
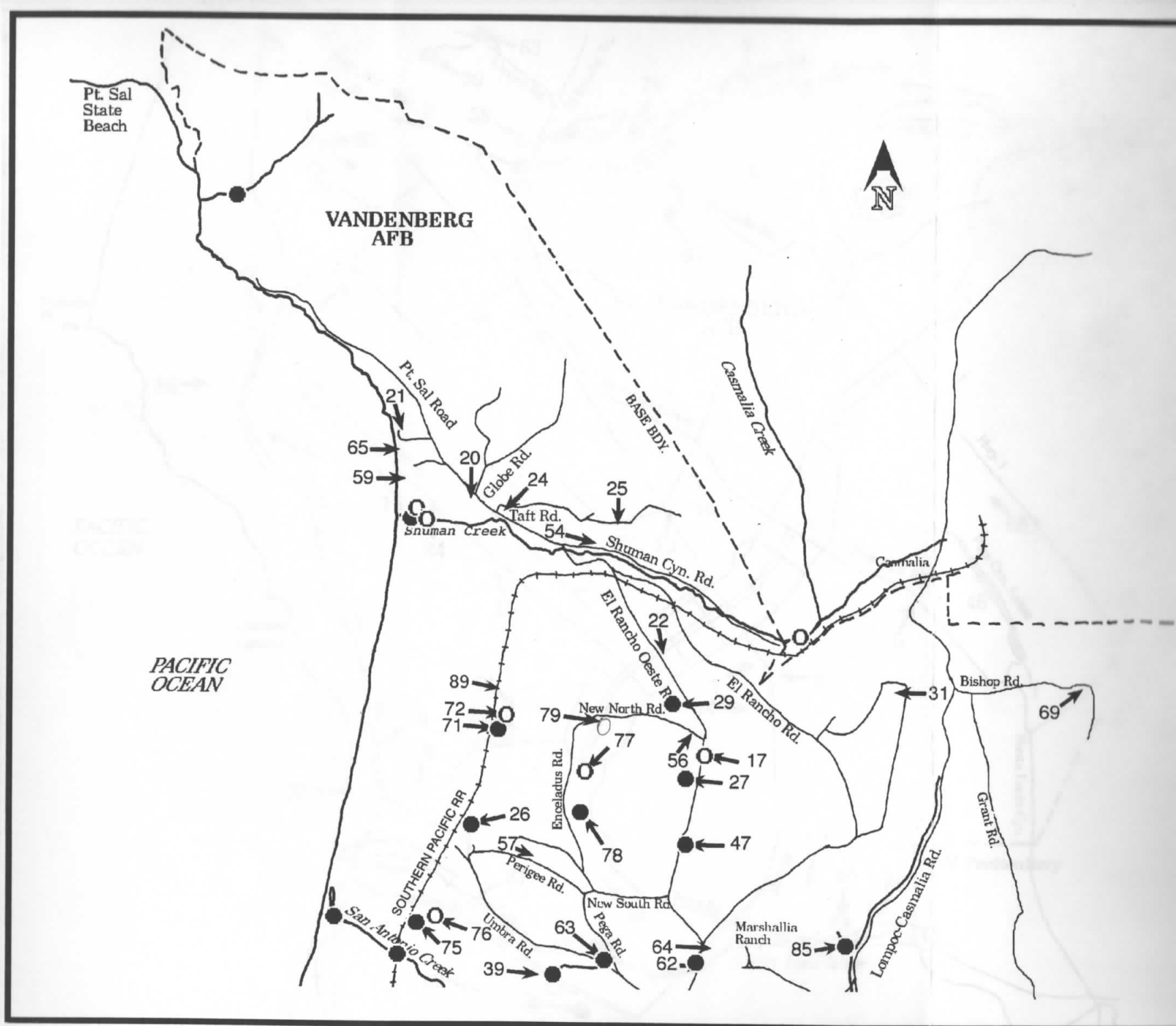
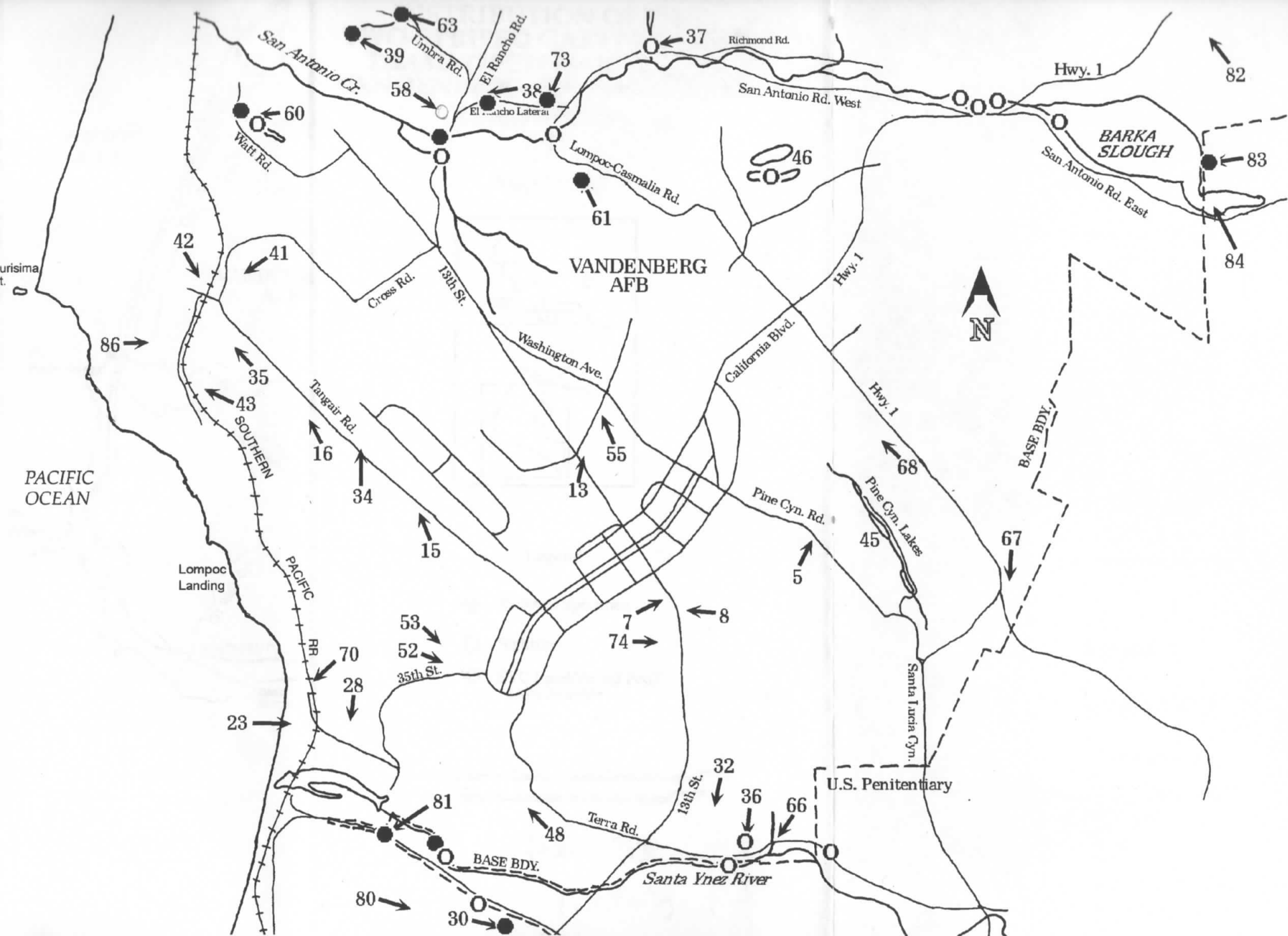


Figure 9. Distribution of the red-legged frog on Vandenberg Air Force Base, California in 1995.





PACIFIC
OCEAN

VANDENBERG
AFB

Pt.
Pedernales

Pt.
Arguello

SOUTHERN PACIFIC RR

Boat
House

Canada Honda
Honda Ridge Rd.

Oil Well Cyn.

Canada Agua Viva

Tranquillon
Mtn.

Canada de los Ladrones

Water Cyn.

87

88

Canada del Jolloru

Long Horn Cyn.

BASE BDY.

Miguelito Rd.

49

50

Santa Ynez Ridge Rd.

Arguello Blvd.

Lompoc Cyn.

Bear Creek Rd.

Bear Cr.

Surf Rd.

Coast Rd.

Union

Central Ave.

HWY. 246

N

JALAMA BEACH
COUNTY PARK



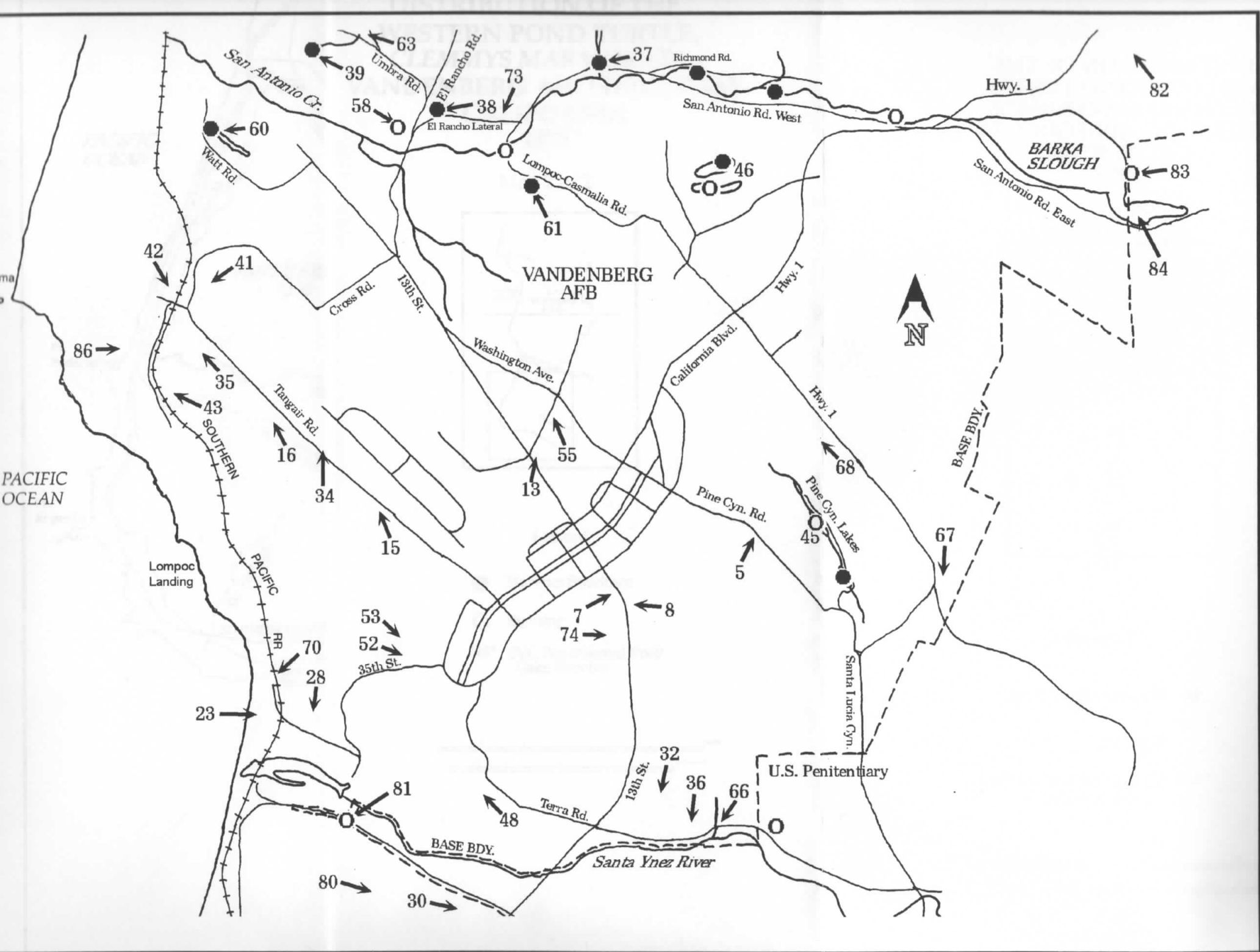
Figure 10. Spring 1995 floods drastically altered habitat at lower Cañada Honda, as seen in summer 1995. In summer 1994 this area had closed-canopy riparian vegetation and a red-legged frog breeding pool.

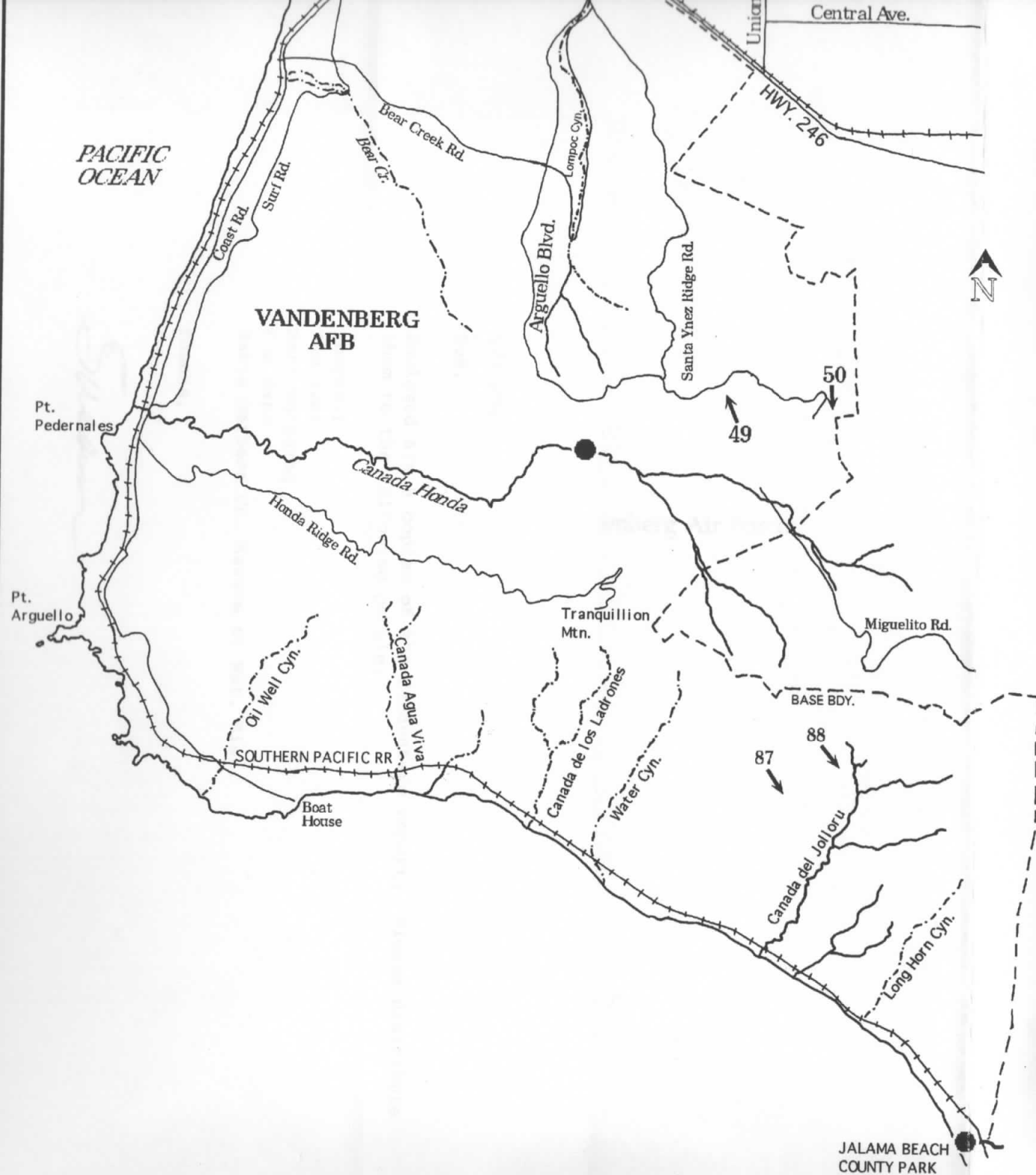


Figure 11. Eucalyptus pond #63 - a productive red-legged frog breeding site.



Figure 12. Distribution of western pond turtle on Vandenberg Air Force Base, California in 1995.





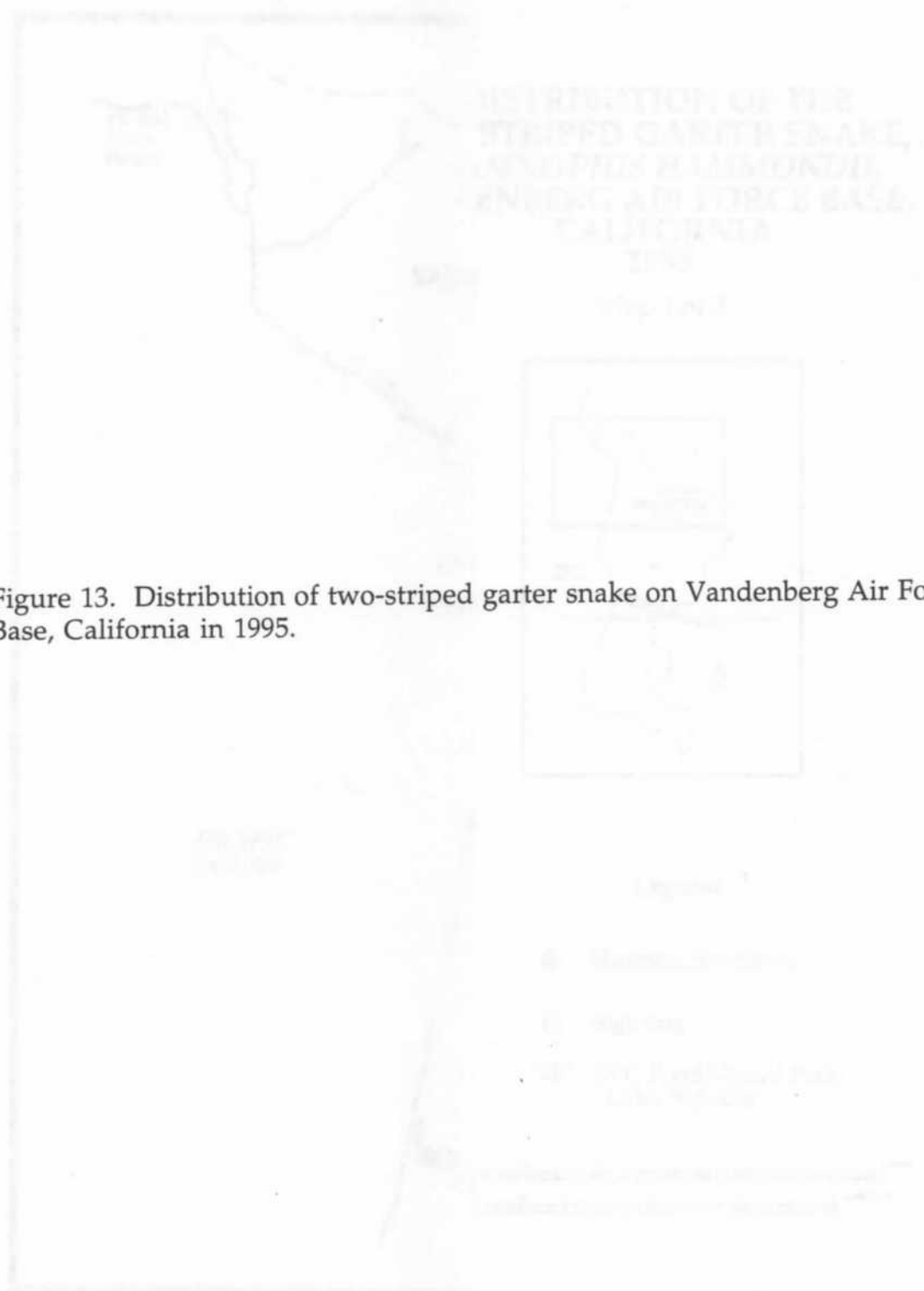
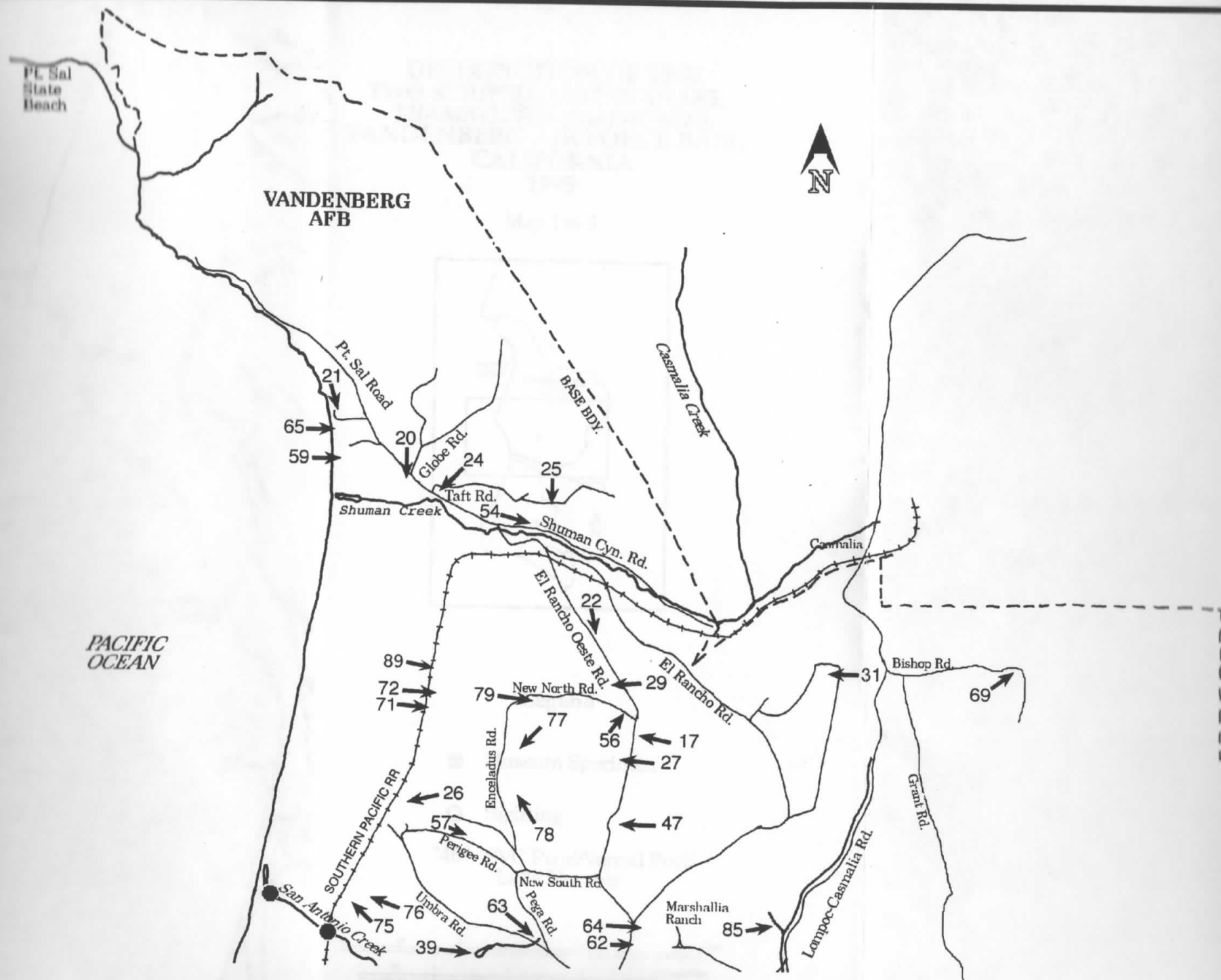
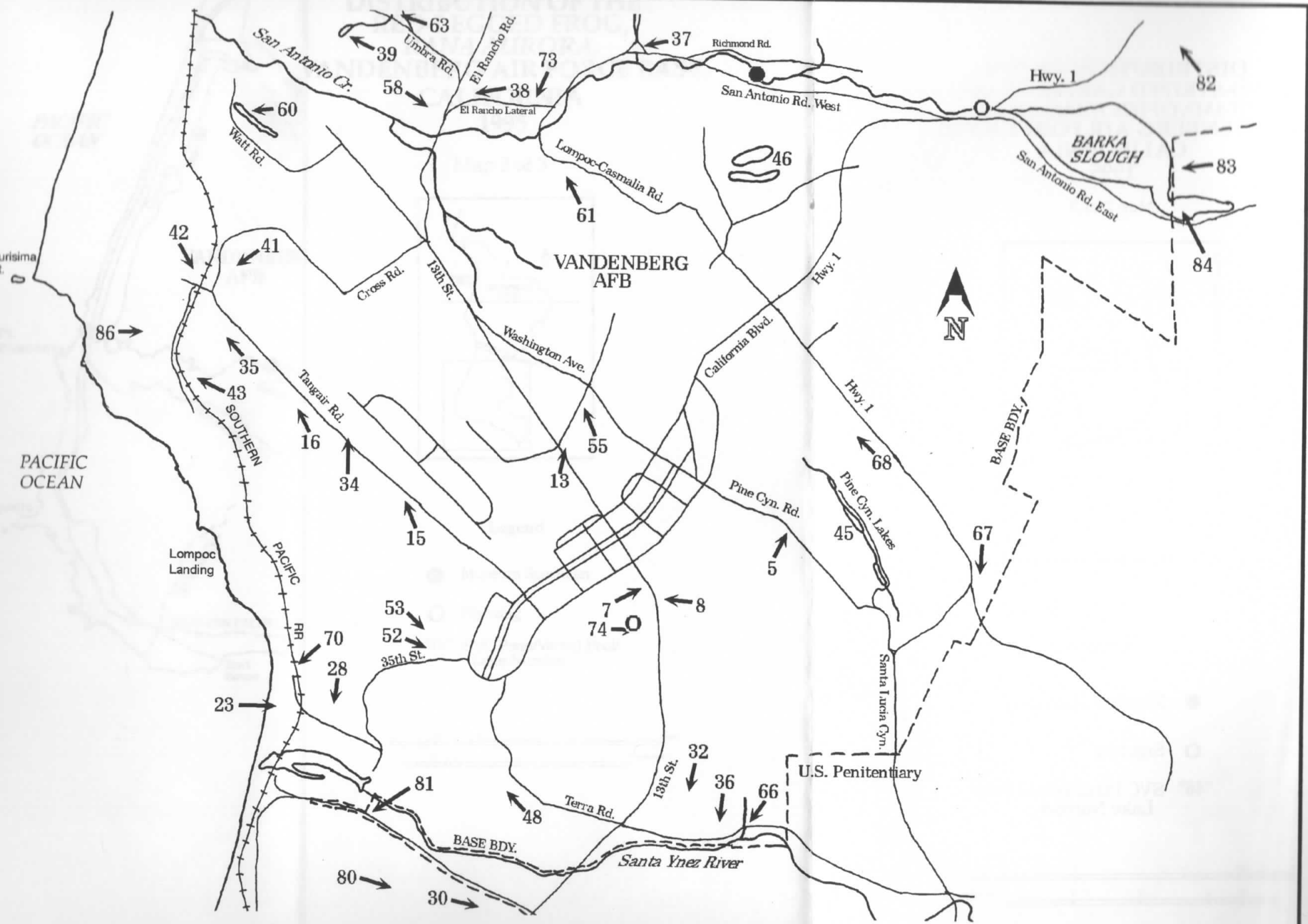
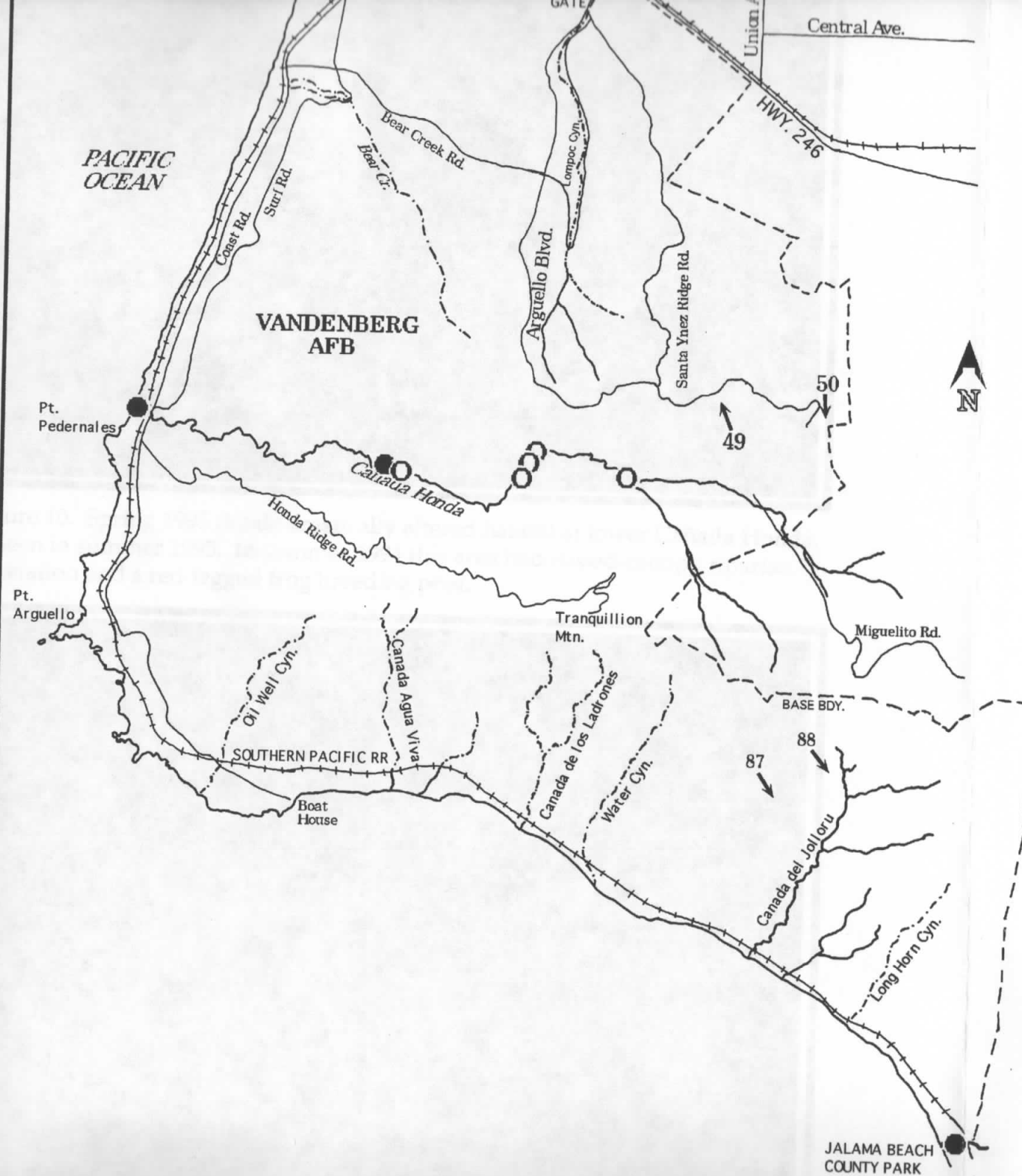


Figure 13. Distribution of two-striped garter snake on Vandenberg Air Force Base, California in 1995.







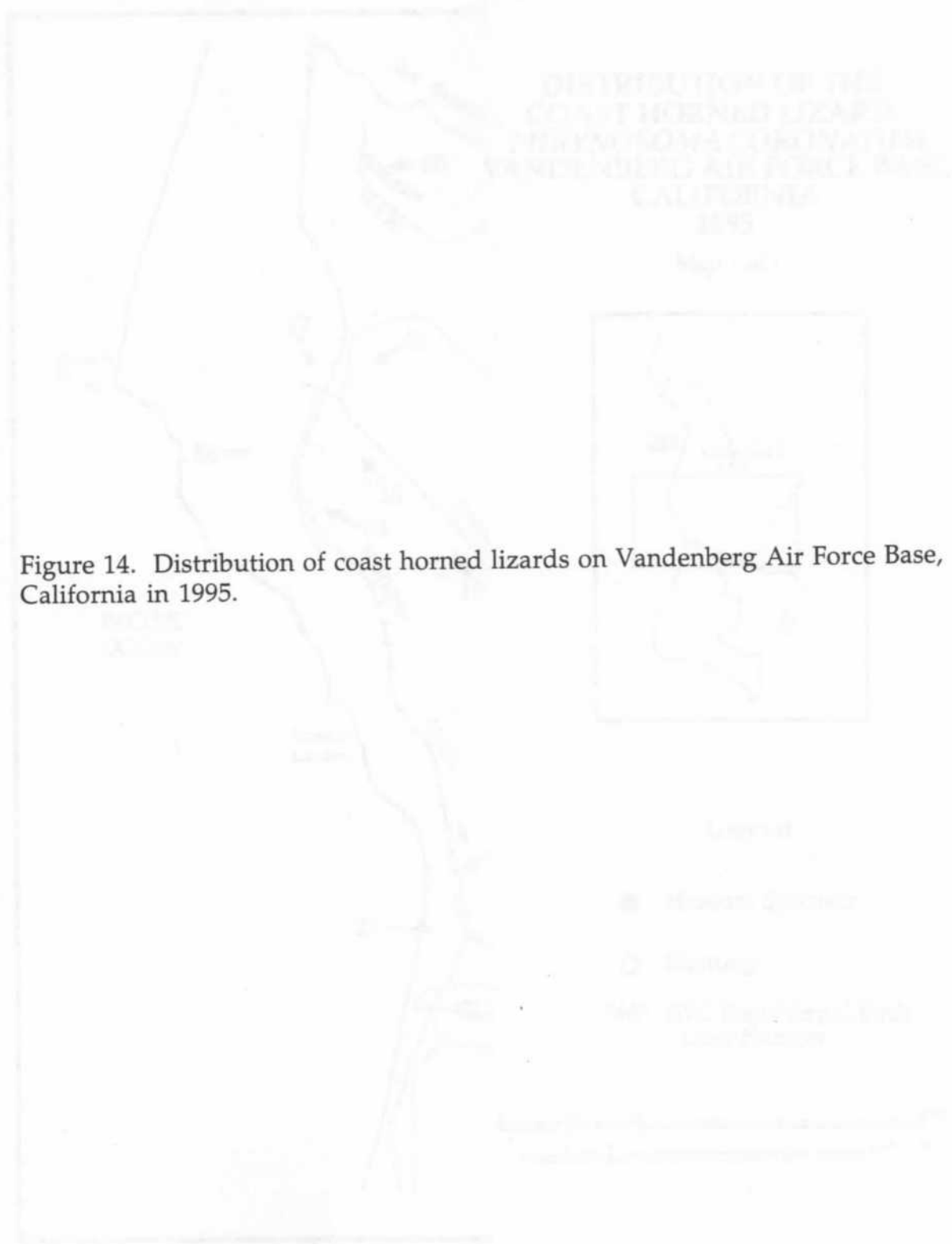
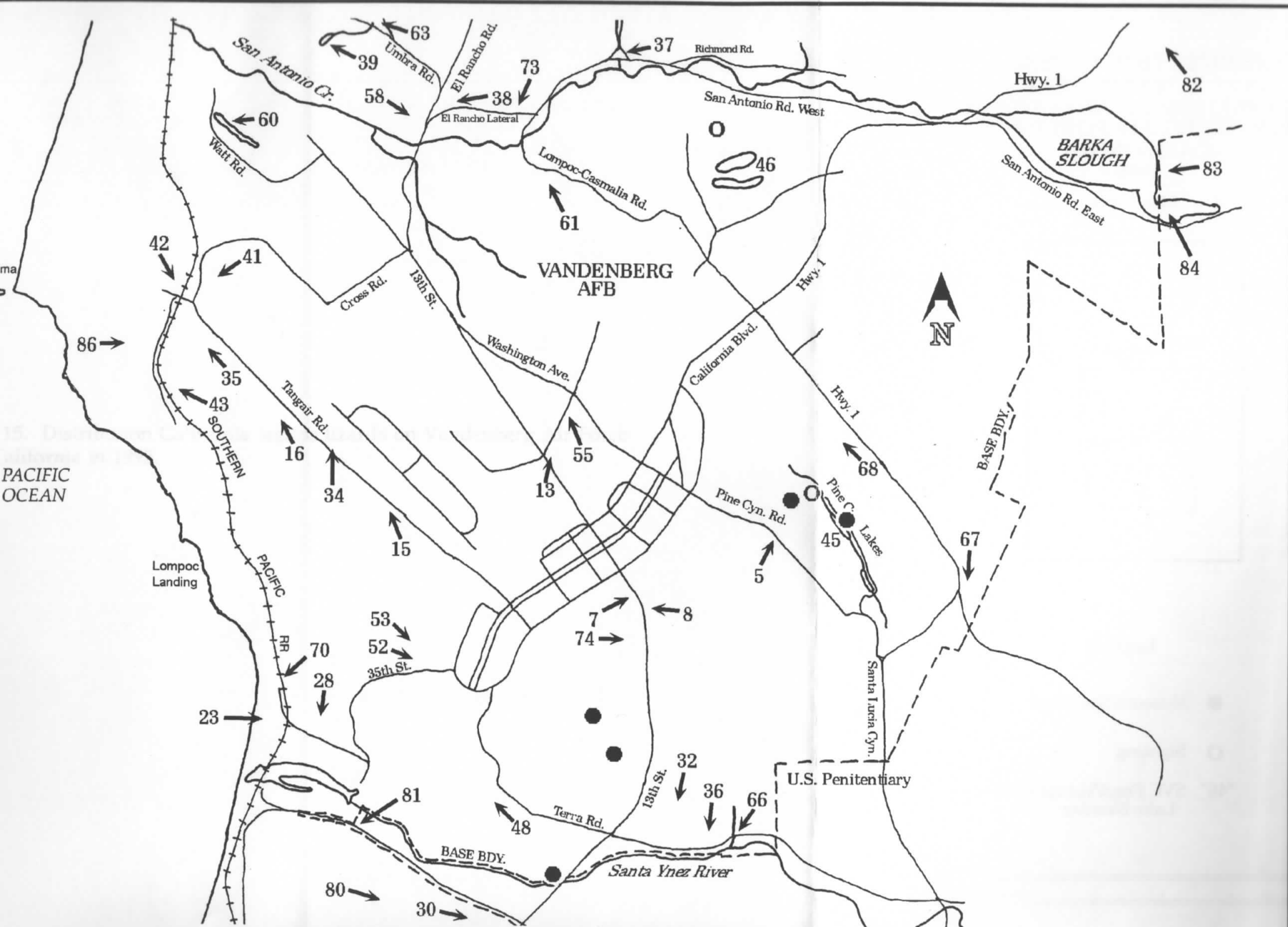


Figure 14. Distribution of coast horned lizards on Vandenberg Air Force Base, California in 1995.



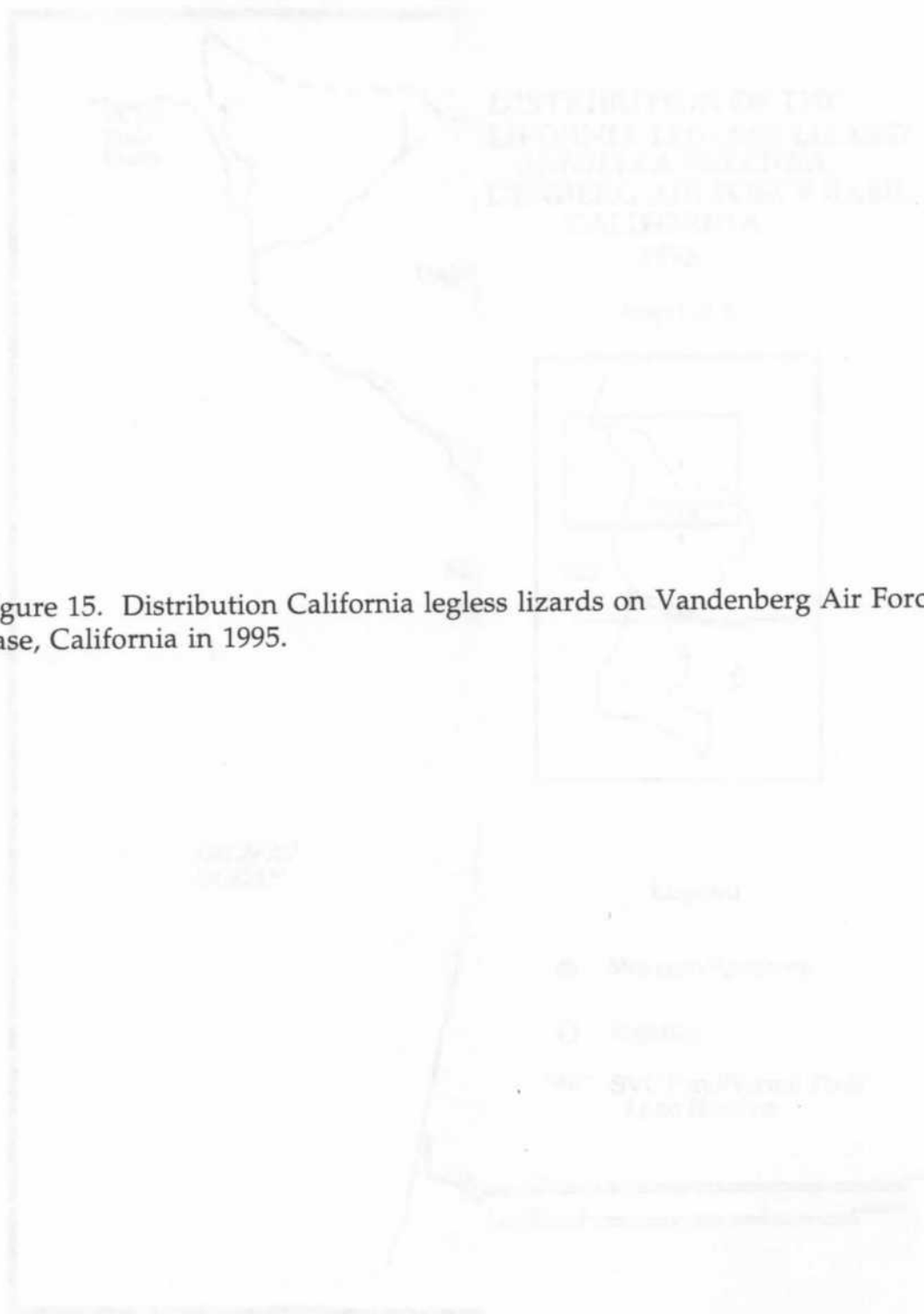
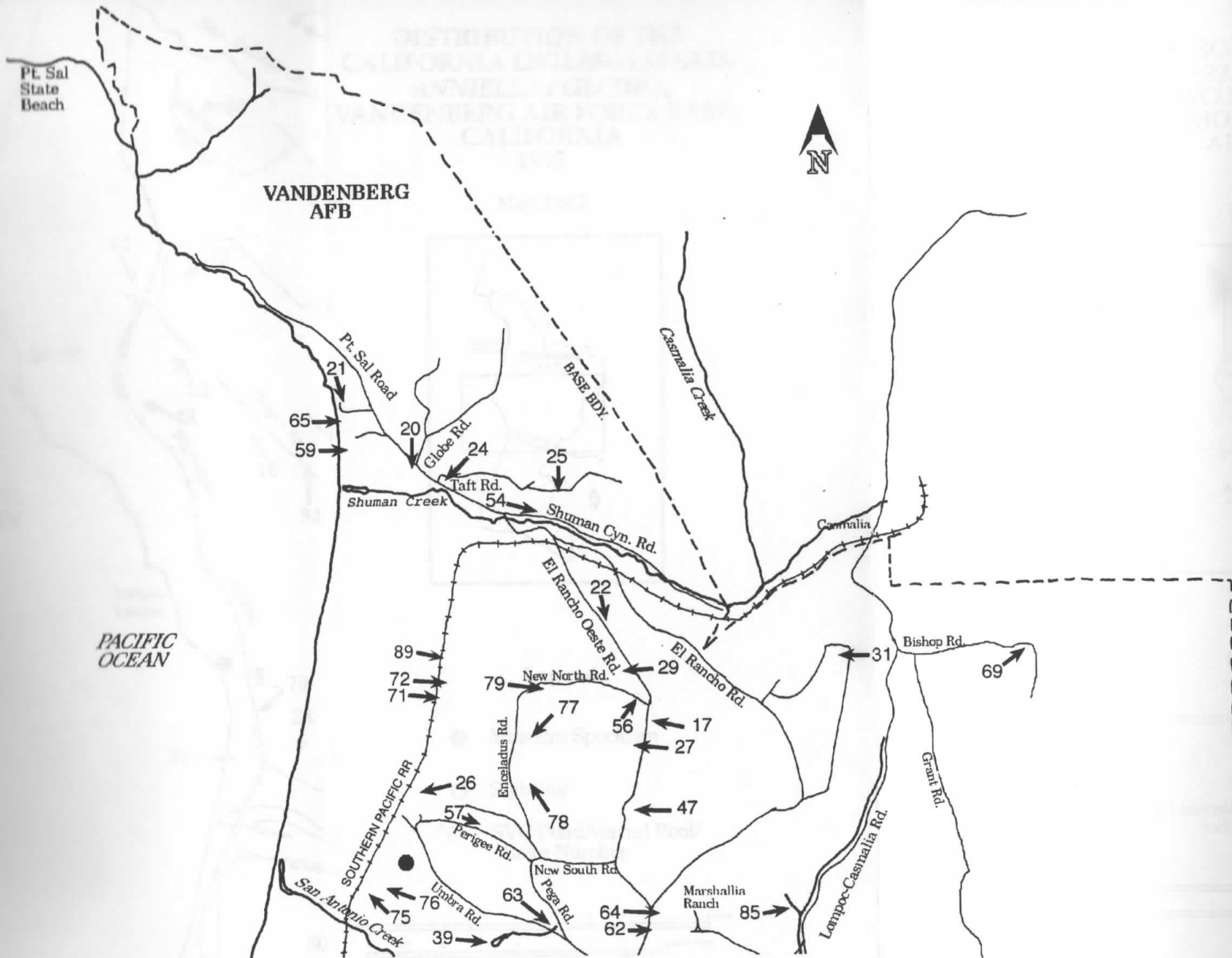
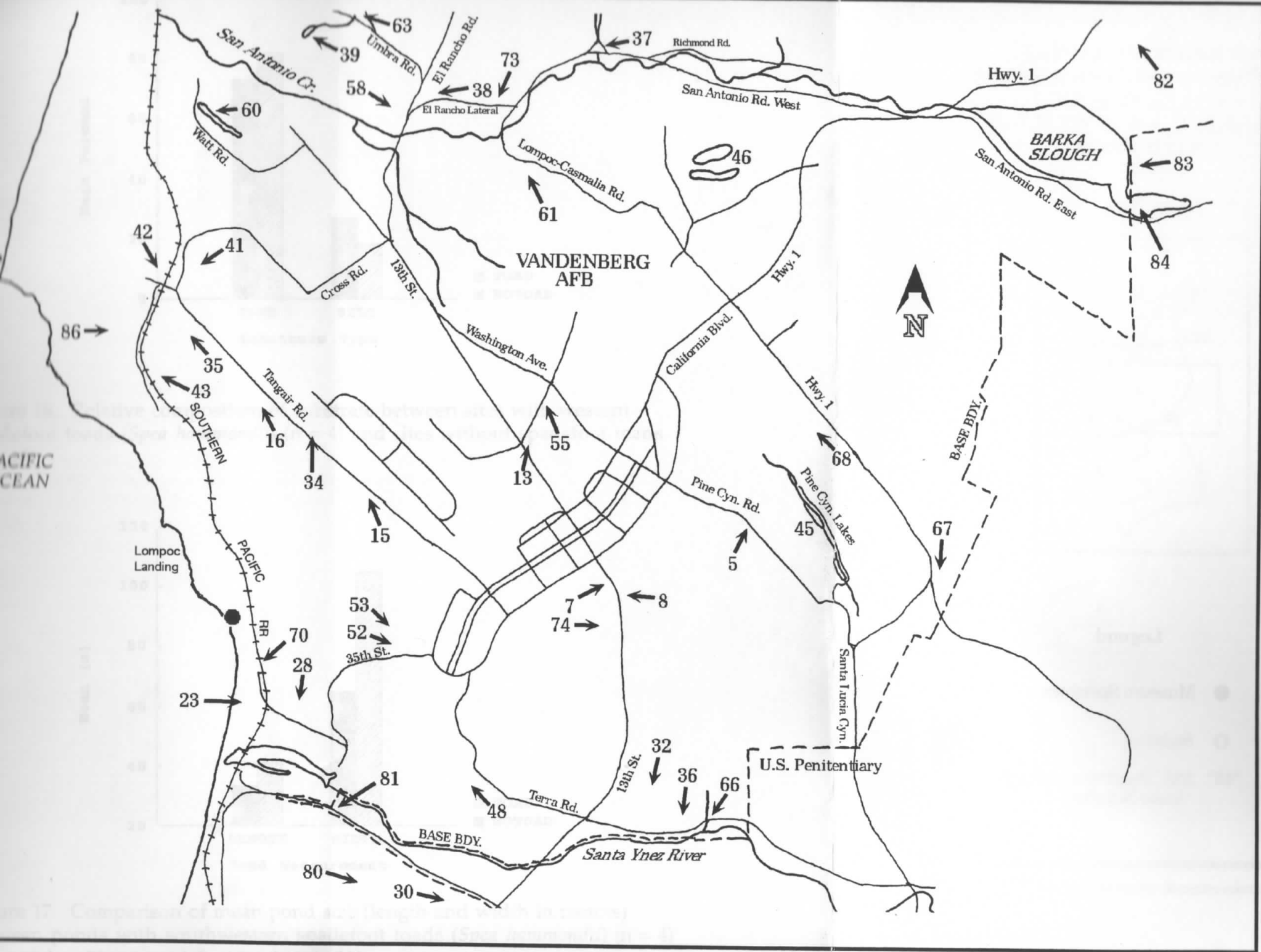


Figure 15. Distribution California legless lizards on Vandenberg Air Force Base, California in 1995.





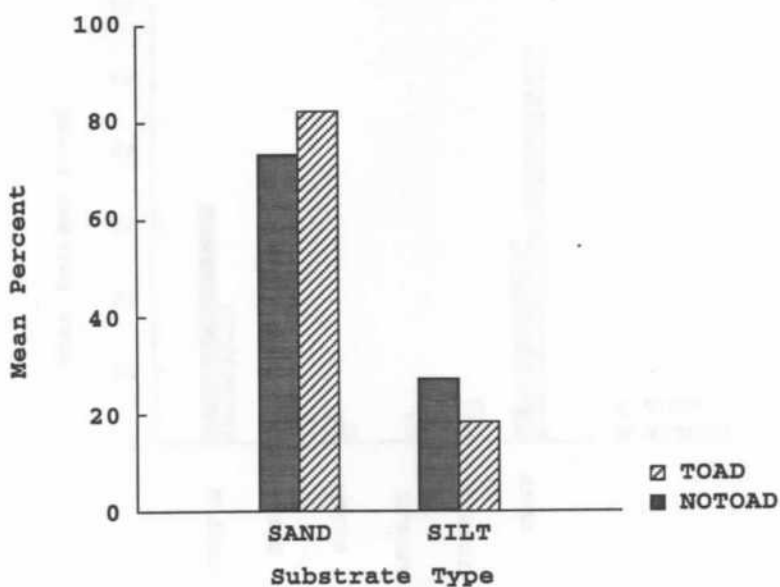


Figure 16. Relative composition of substrate between sites with western spadefoot toads (*Spea hammondi*) (n = 4) and sites without spadefoot toads (n = 16).

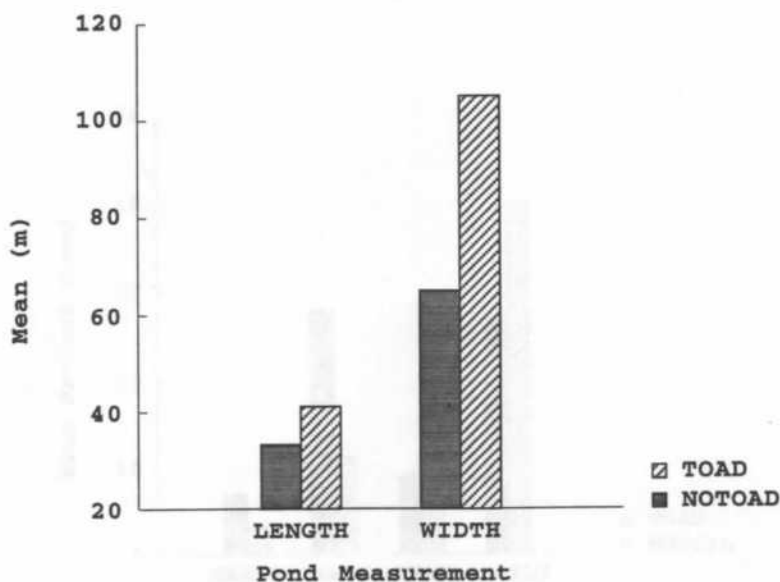


Figure 17. Comparison of mean pond size (length and width in meters) between ponds with southwestern spadefoot toads (*Spea hammondi*) (n = 4) and ponds without spadefoot toads (n = 16).

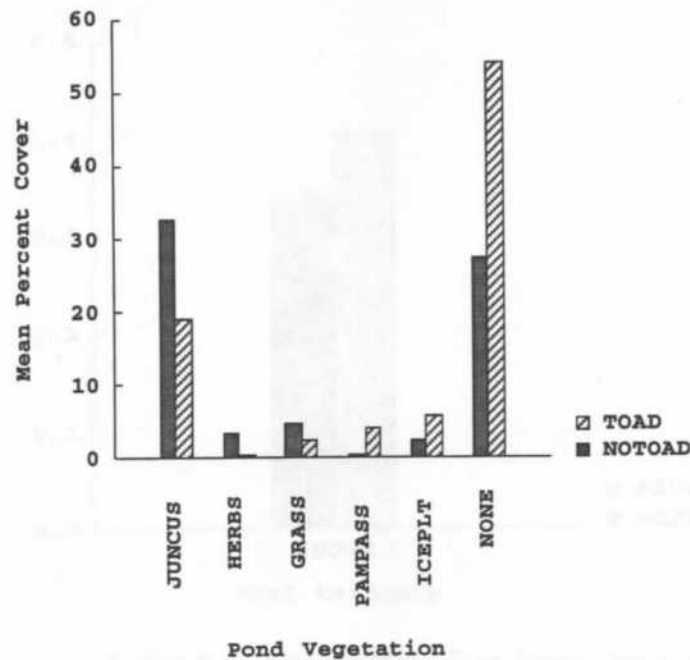


Figure 18. Mean percent cover of dominant vegetation types at ponds with western spadefoot toads (*Spea hammondi*) (n = 4) and ponds without spadefoot toads (n = 16). Vegetation types are denoted by the following codes: rushes (*Juncus* sp.) and sedges (*Carex* sp.) ("JUNCUS"), herbaceous species ("HERBS"), annual grasses ("GRASS"), pampas grass (*Cortaderia* sp.) ("PAMPASS"), iceplant (*Carpobrotus* sp.) ("ICEPLT"), and open water ("NONE").

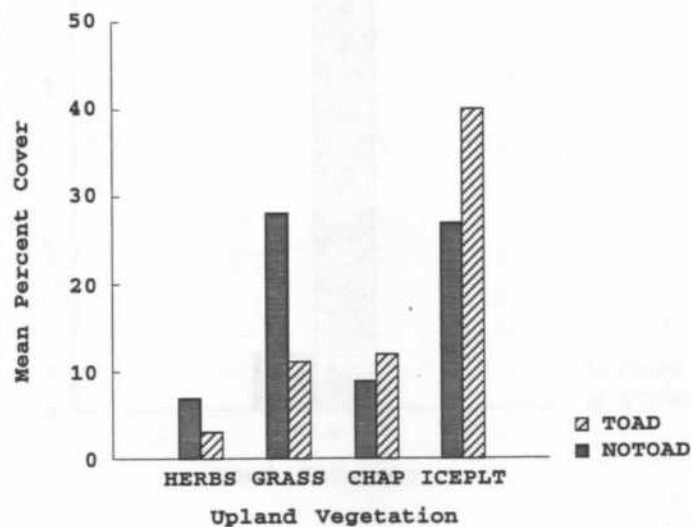


Figure 19. Mean percent cover of dominant upland vegetation types between sites with southwestern spadefoot toads (*Spea hammondi*) (n = 4) and sites without spadefoot toads (n = 16). Vegetation types are denoted by the following codes: herbaceous species ("HERBS"), annual grasses ("GRASS"), coastal sage scrub ("CHAP"), and iceplant (*Carpobrotus* sp.) ("ICEPLT").

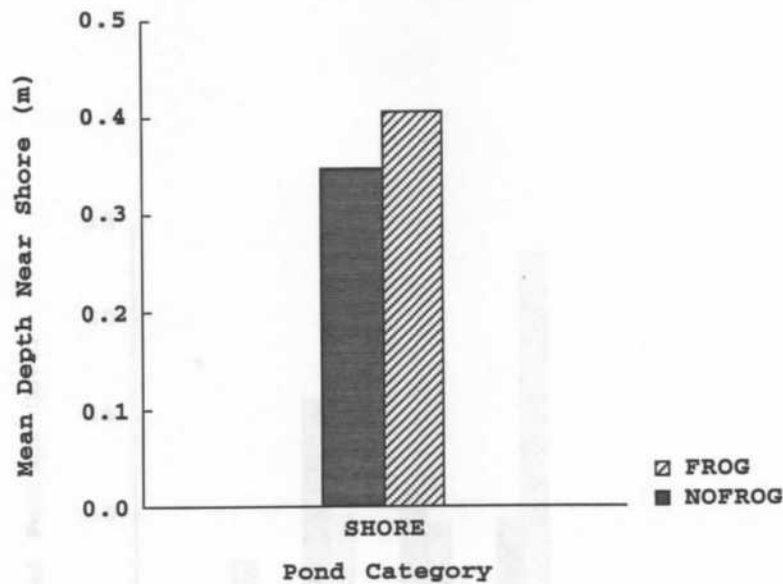


Figure 20. Mean pond depth approximately 5 m from shore at ponds with red-legged frogs (*Rana aurora*) (n=15) and ponds without red-legged frogs (n=21).

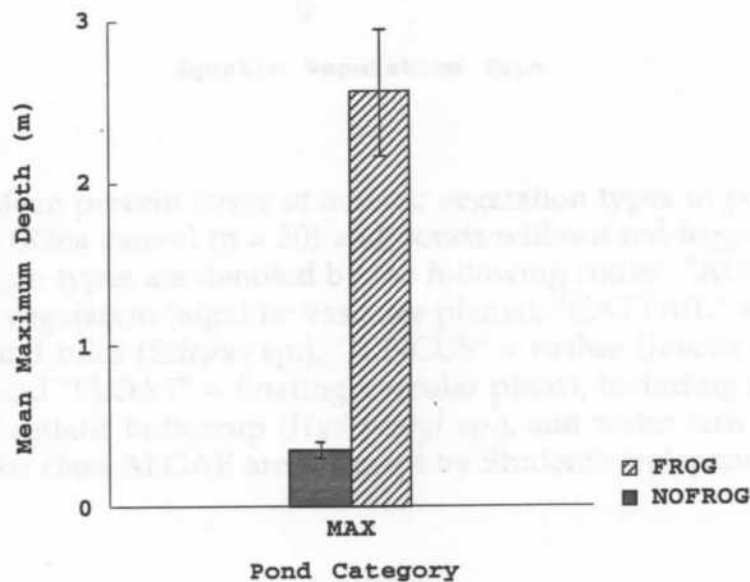


Figure 21. Mean maximum depth of ponds with red-legged frogs (*Rana aurora*) (n=17) and ponds without red-legged frogs (n=7, Student's independent *t*-test $p=0.02$).

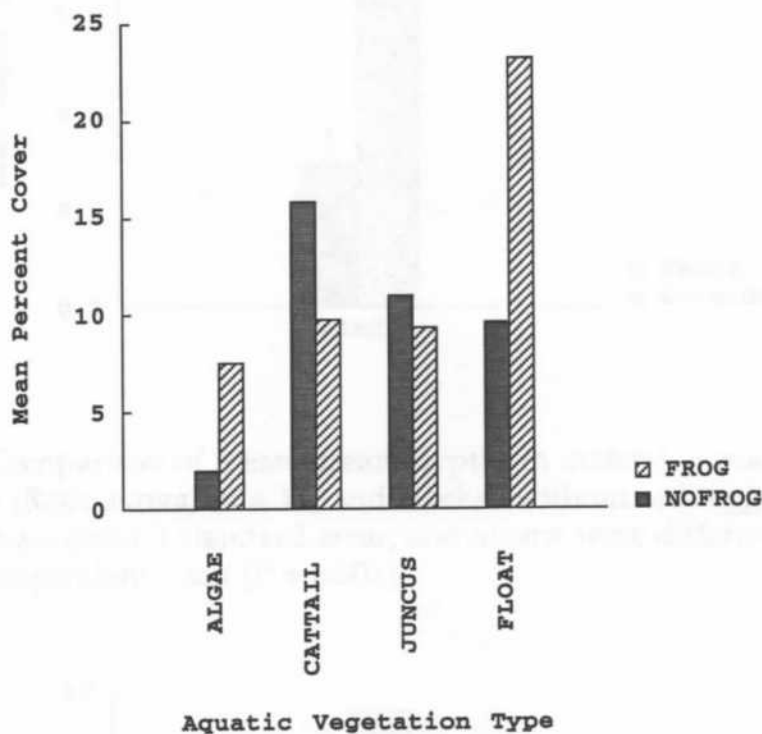


Figure 22. Mean percent cover of aquatic vegetation types in ponds with red-legged frogs (*Rana aurora*) ($n = 20$) and ponds without red-legged frogs ($n = 15$). Vegetation types are denoted by the following codes: "ALGAE" = submergent vegetation (algal or vascular plants), "CATTAIL" = cattails (*Typha* sp.) and tules (*Scirpus* sp.), "JUNCUS" = rushes (*Juncus* sp.) and sedges (*Carex* sp.), and "FLOAT" = floating vascular plants, including duckweed (*Lemna* sp.), aquatic buttercup (*Hydrocotyl* sp.), and water fern (*Azolla* sp.). The means for class ALGAE are different by Student's independent t -test ($P = 0.048$).

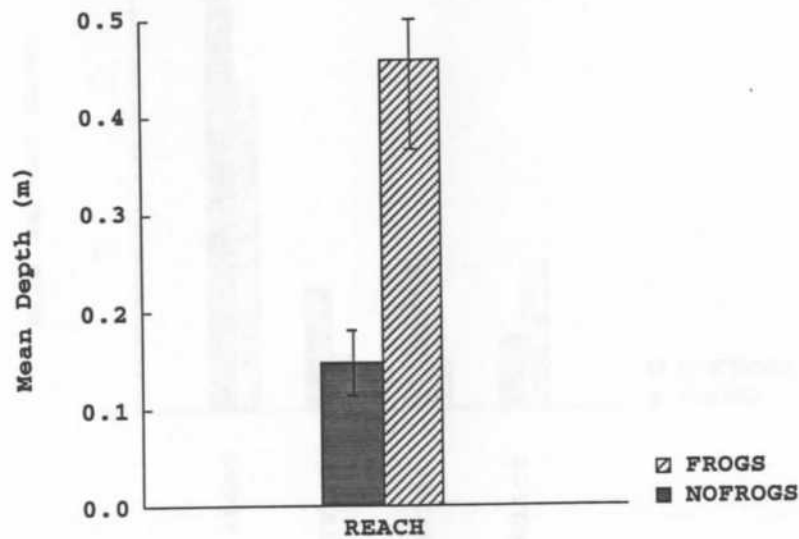


Figure 23. Comparison of mean stream depth (in meters) at reaches with red-legged frogs (*Rana aurora*) ($n = 11$) and reaches without red-legged frogs ($n = 9$). Vertical bars show 1 standard error, and means were different by a Student's independent t -test ($P = 0.001$).

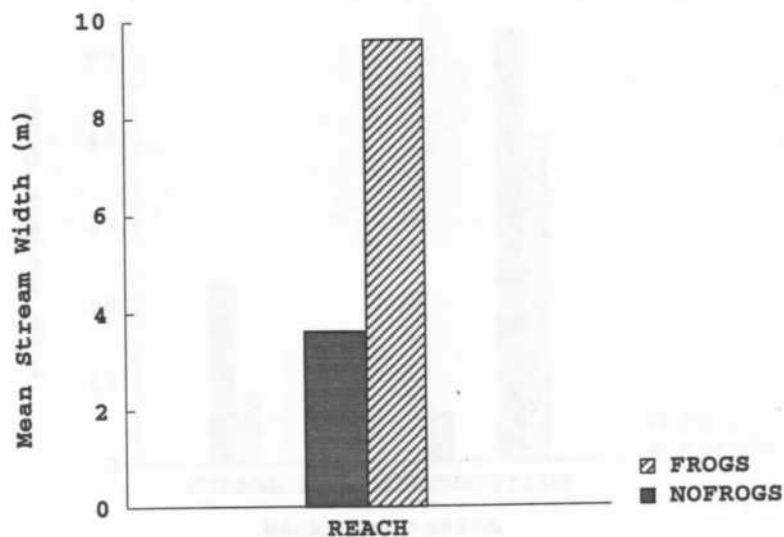


Figure 24. Comparison of mean stream width (in meters) at reaches with red-legged frogs (*Rana aurora*) ($n = 11$) and reaches without red-legged frogs ($n = 9$).

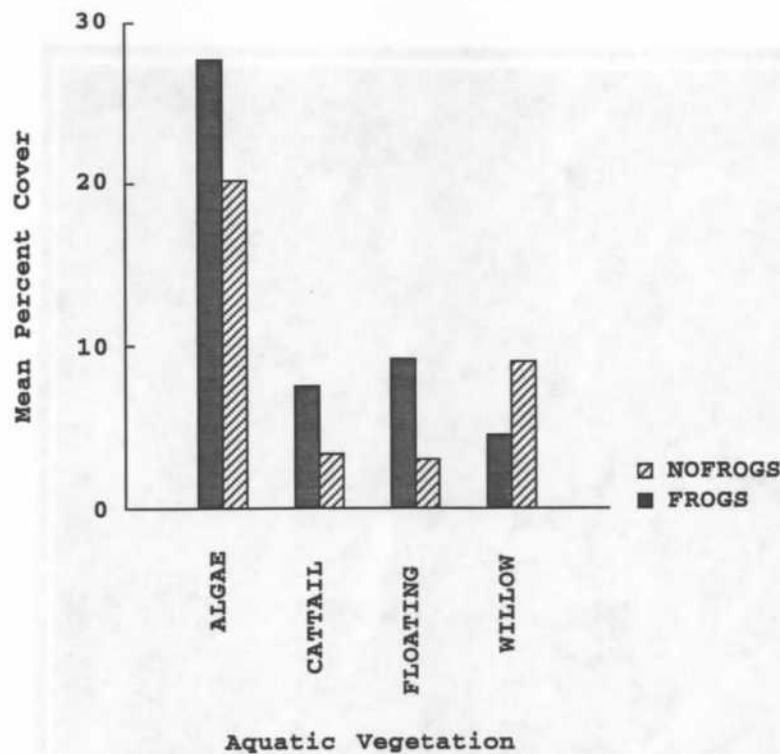


Figure 25. Mean percent cover of dominant aquatic vegetation types at stream reaches with red-legged frogs (*Rana aurora*) (n = 11) and stream reaches without red-legged frogs (n = 10).

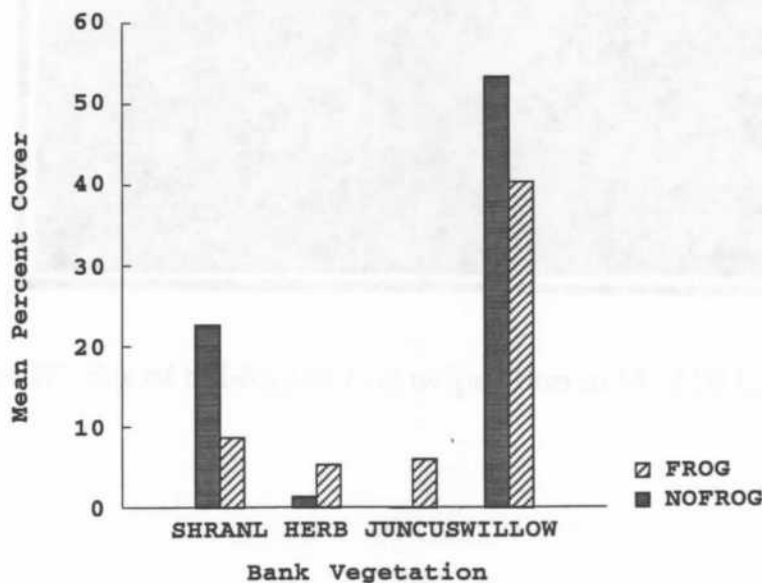


Figure 26. Mean percent cover of dominant bank vegetation types at stream reaches with red-legged frogs (*Rana aurora*) (n = 11) and stream reaches without red-legged frogs (n = 9). Vegetation types are "SHRANL"= stinging nettle (*Urtica* sp.), poison oak (*Toxicodendron* sp.), blackberry (*Rubus* sp.) and others; "HERB"=various herbaceous species less than 0.5 m high; "JUNCUS"=rushes (*Juncus* sp.) and sedges (*Carex* sp.); "WILLOW"=willows (*Salix* sp.). "SHRANL" is greater for sites without frogs by a Student's independent *t*-test ($P = 0.04$).



Figure 27. Site of red-legged frog oviposition in Mod III Lake (site #39).

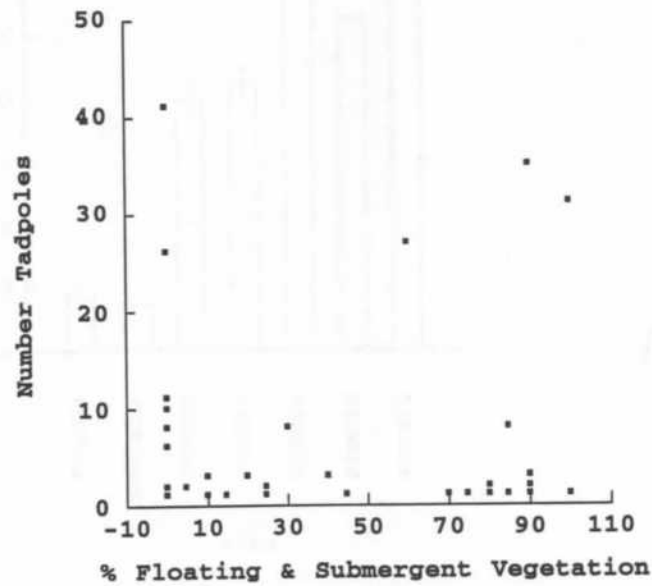


Figure 28. Number of red-legged frog (*Rana aurora*) tadpoles trapped by percent cover by floating aquatic plants, duckweed (*Lemna* sp.), aquatic buttercup (*Hydrocotyl* sp.), and water fern (*Azolla* sp.), and submergent vegetation (algae and submergent macrophytes) within m².

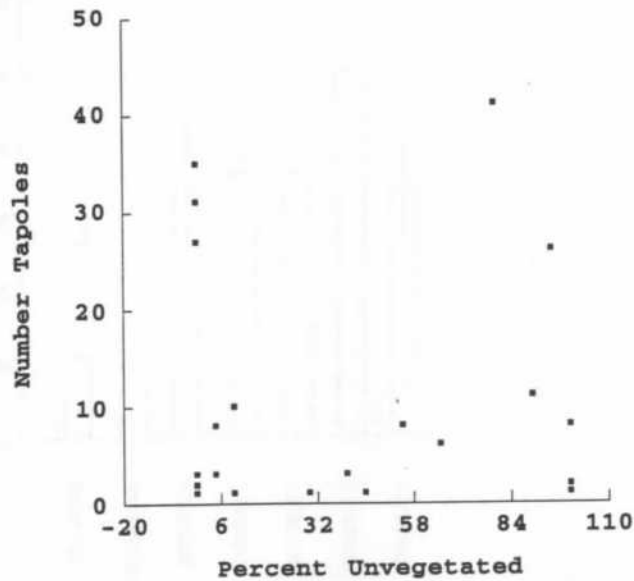


Figure 29. Number of red-legged frog (*Rana aurora*) tadpoles trapped by percent unvegetated area within m².

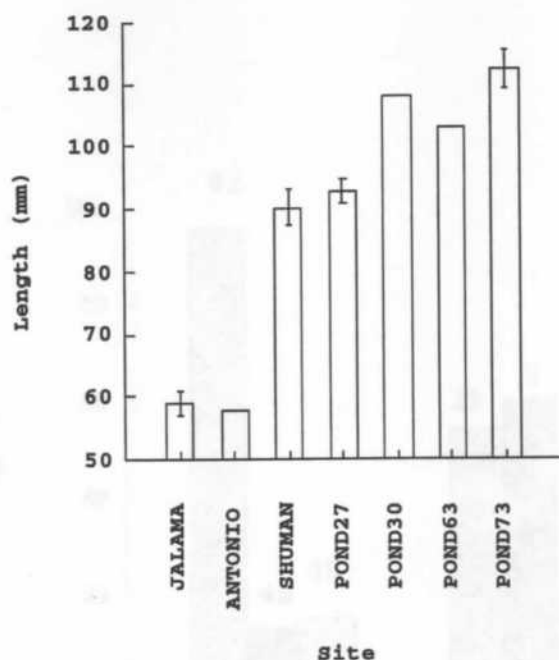


Figure 30. Mean total length of red-legged frog (*Rana aurora*) tadpoles measured in early July 1995 from lagoon and pond sites at Vandenberg Air Force Base, California. Standard error bars are absent from sites with only one observation. Most observations were from Jalama lagoon (n=27) and Pond 27 (n=48).

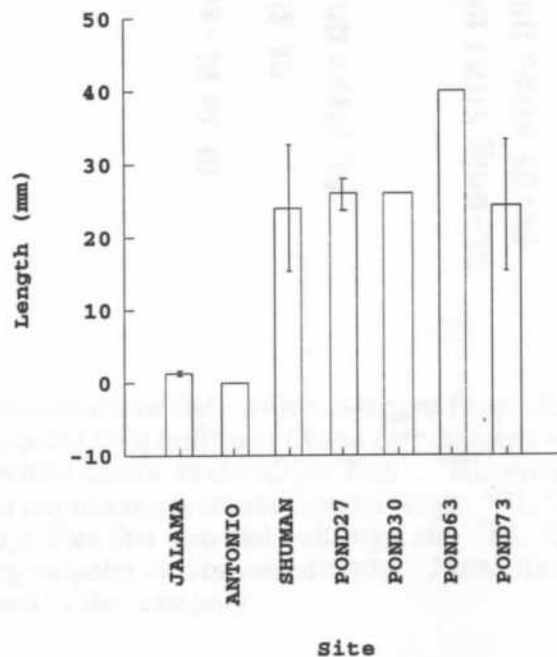


Figure 31. Mean hind leg length of red-legged frog tadpoles measured in early July 1995 from lagoon and pond sites at Vandenberg Air Force Base, California. Standard error bars are absent from sites with only one observation. Most observations were from Jalama lagoon (n=27) and Pond 27 (n=48).

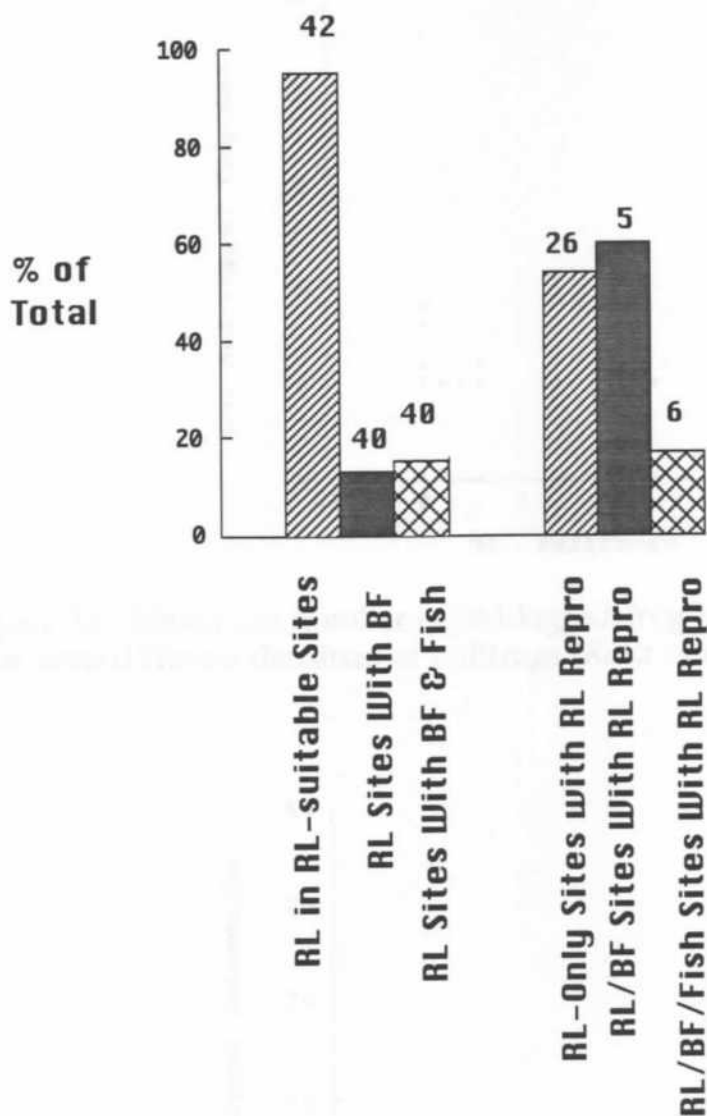


Figure 32. Comparison of sites with red-legged frogs (*Rana aurora*) = "RL" alone to sites where they co-occur with bullfrogs (*Rana catesbeiana*) = "BF" and introduced predatory fishes (centrarchids and/or ictalurids) = "Fish". "RL-suitable" sites are those which appeared to meet habitat requirements for red-legged frogs. "RL Sites With BF" is the percent of red-legged frogs sites that also had bullfrogs, etc. "RL Repro" indicates presence of red-legged frog tadpoles and/or metamorphs. Numbers above bars indicate the total number of sites surveyed in that category.

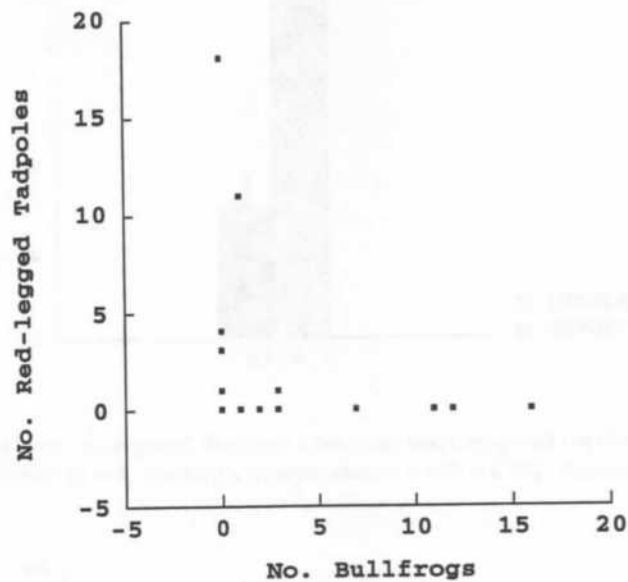


Figure 33. Maximum number of red-legged frog tadpoles (*Rana aurora*) at sites with different densities of bullfrogs (*Rana catesbeiana*) ($P=0.18$, $r^2=0.057$).

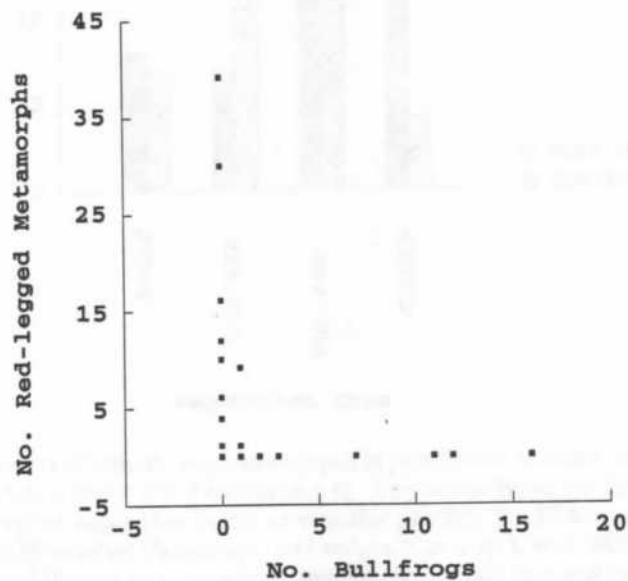


Figure 34. Maximum number of red-legged frog metamorphs (*Rana aurora*) observed at sites with different densities of bullfrogs (*Rana catesbeiana*) ($P=0.14$, $r^2=0.07$).

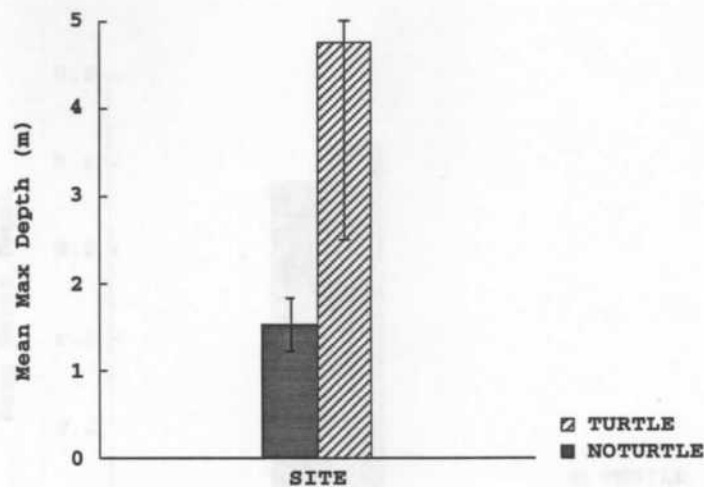


Figure 35. Comparison of maximum pond depth at sites with western pond turtles (*Clemmys marmorata*) (n = 5) to sites without pond turtles (n = 4, Student's independent *t*-test $P = 0.08$). Bars are one standard error.

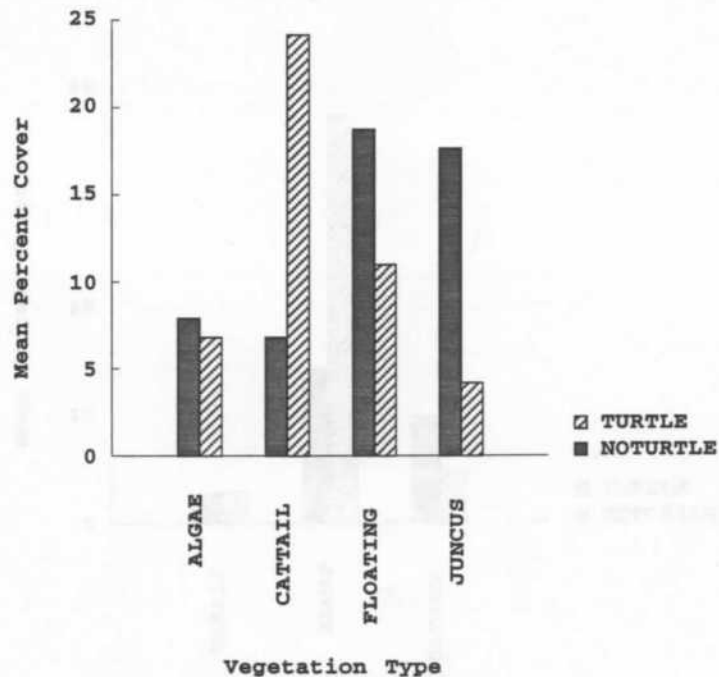


Figure 36. Mean percent cover of aquatic vegetation types in ponds with western pond turtles (*Clemmys marmorata*) (n = 8) and ponds without pond turtles (n = 6). Vegetation types are denoted by the following codes: "ALGAE"=submergent vegetation (algal or vascular plants), "CATTAIL"=cattails (*Typha* sp.) and tules (*Scirpus* sp.), "JUNCUS"=rushes (*Juncus* sp.) and sedges (*Carex* sp.), and "FLOAT"=floating vascular plants, including duckweed (*Lemna* sp.), aquatic buttercup (*Hydrocotyl* sp.) and water fern (*Azolla* sp.). The means for class CATTAIL are different by Student's independent *t*-test ($P = 0.07$).

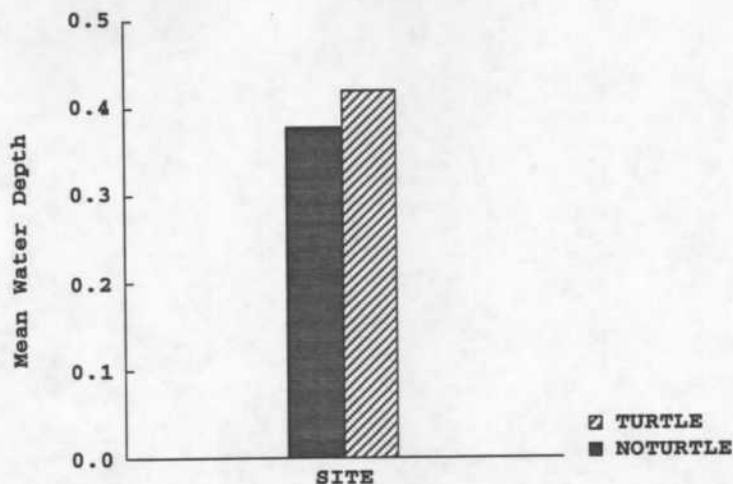


Figure 37. Mean water depth at stream reaches with western pond turtles (*Clemmys marmorata*) (n = 6) and reaches without pond turtles (n = 5).

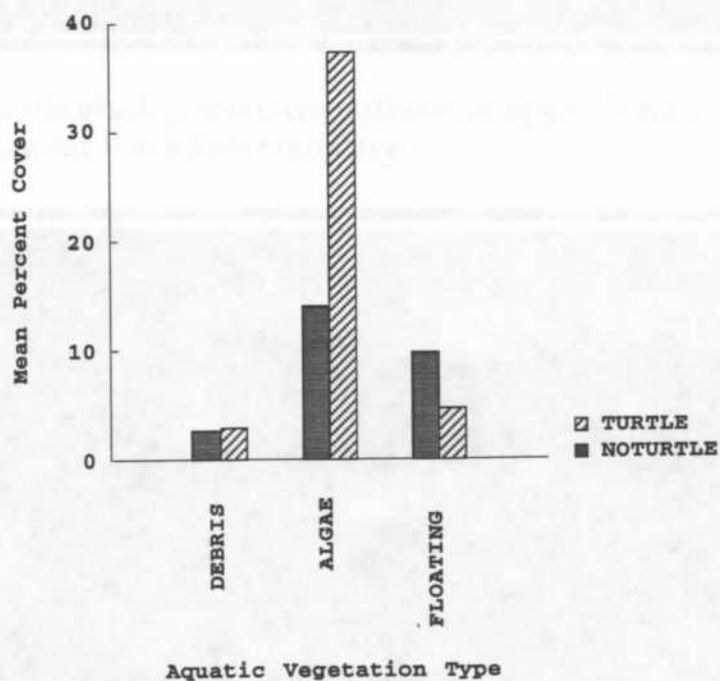


Figure 38. Mean percent cover of aquatic vegetation types in stream reaches with western pond turtles (*Clemmys marmorata*) (n = 5) and ponds without pond turtles (n = 6). Vegetation types are denoted by the following codes: "DEBRIS"=floating vegetative matter, "ALGAE"=submergent vegetation (algal or vascular plants), and "FLOAT"=floating vascular plants, including duckweed (*Lemna* sp.), aquatic buttercup (*Hydrocotyl* sp.), and water fern (*Azolla* sp.).



Figure 39. Cattle grazing and incised stream at upper Cañada Honda, just east of Vandenberg Air Force Base boundary.



Figure 40. Eroded stream banks in Cañada Honda, Vandenberg Air Force Base, may impede movement of reptiles and amphibians to upland sites.



Figure 41. Productive site (#87) for red-legged frog metamorphs in 1995, with shoreline denuded of vegetation by livestock grazing, Sudden Ranch, Vandenberg Air Force Base, California.



Figure 42. Lower San Miguelito and Lompoc Creeks impacted by livestock grazing. Red-legged frogs and pond turtles are known from < 0.2 km downstream of this site.



Figure 43. Silt deposition resulting in stream flow changes at Lompoc-Casmalia Road crossing of San Antonio Creek, Vandenberg Air Force Base, California from spring 1995 storms.



Figure 44. San Antonio Creek, Vandenberg Air Force Base, California, downstream of beaver dam. This site is too shallow for red-legged frogs and western pond turtles.



Figure 45. San Antonio Creek, Vandenberg Air Force Base, California immediately upstream from beaver dam. This is potentially suitable habitat for red-legged frogs and western pond turtles.

Table 1. Key to sites referenced on maps in Figure 2. These localities are also used in Tables 2 through 8.

Site	Map	Description
1	4	Small rain pool in lawn
2	4	Small rain pool at head of creek
3	4	Small rain pool in lawn
4	4	Small vernal pools (at least 3)
5	2	Small vernal pool
6	4	Series of shallow vernal pools in low area along road
7	2, 4	Small vernal pool
8	2	Small vernal pool, & disturbed seep at head of cyn
9	4	Small vernal pool at head of canyon
10	4	Small vernal pool
11	4	Small vernal pool
12	4	Small vernal pool, & ditch
13	2	Small vernal pools
14	4	Large vernal pool
15	2	Medium size vernal pool
16	2	Medium size vernal pool, & pit ponds
17	1	Ephemeral pond, not well vegetated
18	4	Disturbed vernal pool, & small vernal pools
19	4	Small vernal pool
20	1	Small vernal pool
21	1	Ephemeral dune swale pool
22	1	Small vernal pool/ditch
23	2	hypersaline lake
24	1	Small vernal pool
25	1	Small vernal pool
26	1	Created dune swale pond, "Wildflower Wetland"
27	2	Created dune swale pond, "Live Oak Wetland"
28	2	Large vernal pool
29	1	Cattle pond and marsh
30	2	Two created ponds, one permanent, one ephemeral
31	1	Medium vernal pool, & pit pond
32	2	Small vernal pool
33	4	Small vernal pool
34	2	Large vernal pool
35	2	Large vernal pool
36	2	Created ephemeral ponds
37	2	Permanent beaver pond, "Triangle Pond"
38	2	Permanent pond
39	1	"Mod III Lake"
40	4	Medium vernal pool
41	2	Large lake in steep canyon
42	2	Medium vernal pool/permanent pond

Table 1. Continued.

Site	Map	Description
43	2	Pit pond
44	4	Small vernal pool
45	2	"Pine Cyn. Lakes" (3)
46	2	"Punchbowl Lake"
47	1	Medium dune swale pond
48	2	Created duck ponds (6)
49	3	Small vernal pool/cattle pond
50	3	Small vernal pools/cattle ponds (3)
51	4	Medium vernal pool
52	2	Large vernal pool
53	2	Large vernal pool
54	1	Small vernal pool
55	2	Flooded uplands/ephemeral pond
56	1	Flooded uplands/ephemeral pond
57	1	Flooded uplands/ephemeral pond
58	2	Gravel pit
59	1	Several ephemeral dune swale ponds
60	2	Lake in steep canyon
61	2	Permanent beaver pond
62	1	Small permanent pond in eucalyptus
63	1	Small permanent pond in eucalyptus
64	1	Concrete-lined golf course pond
65	1	Ephemeral dune swale pond
66	2	Small permanent pond
67	2	Large ephemeral pond
68	2	Medium permanent pond, & medium ephemeral pond
69	1	Wastewater ponds (3)
70	2	Small vernal pool/cattle pond
71	1	Permanent dune swale pond
72	1	Permanent dune swale pond
73	2	Medium permanent pond in eucalyptus
74	2	Pit pond
75	1	Permanent dune swale pond
76	1	Permanent dune swale pond
77	1	Permanent dune swale pond
78	1	Permanent dune swale pond
79	1	Ephemeral dune swale pond
80	2	Ephemeral pond/cattle pond
81	2	Permanent pond at end of channelized creek
82	2	Ephemeral cattle pond
83	2	Ephemeral irrigation pond
84	2	Permanent irrigation pond
85	1	Permanent pond/marsh in canyon
86	2	Ephemeral pond
87	3	Permanent cattle lake
88	3	Ephemeral cattle pond
89	1	Permanent dune swale
90	4	Small semi-permanent or permanent pond

Table 1. Continued.

Site	Map	Description
ANTONIO LAGOON	1	Lagoon
ANTONIO AT SPRR	1	Perennial stream, deep
ANTONIO TURTLE MARSH	2	Ephemeral marsh
ANTONIO AT EL RANCHO	2	Perennial stream, deep
ANTONIO MARSH S TRIB	2	Permanent marsh
ANTONIO AT L-C RD.	2	Perennial stream
ANTONIO RD. W	2	Perennial stream, shallow
ANTONIO AT RECYC CTR	2	Perennial stream, shallow
ANTONIO AT STATE WATER	2	Perennial stream, shallow
ANTONIO AT HWY. 1	2	Perennial stream, shallow
BEAR VALLEY	3	Ephemeral lake
CANADA DE LAS LADRONES	3	Intermittent stream
CREEK E OF JOLLORU	3	Small perennial stream
DITCH 13TH ST	2	Shallow concrete-lined ditch
EL RANCHO ERODED	1	Eroded seep/spring
HONDA LAGOON-COAST RD	3	Lagoon
HONDA CYN RD 1-3 XING	3	Perennial stream, shallow
HONDA AT POWER LINE	3	Perennial stream, shallow
HONDA TRANQ. MTN RD.	3	Perennial stream, shallow
HONDA AT E BASE BDY.	3	Perennial stream, shallow
JALAMA LAGOON-SPRR	3	Lagoon
JOLLORU	3	Perennial stream, shallow
LOMPOC CYN	3	Small perennial stream
LONG HORN CYN	3	Intermittent stream
OCEAN AVE DITCH	2	Channelized stream
OIL WELL CYN	3	Intermittent stream
NEAR PT SAL	1	Small perennial stream
SHUMAN LAGOON	1	Lagoon and lower stream
SHUMAN AT PT SAL RD	1	Intermittent stream
CASMALIA/SHUMAN	1	Perennial stream
SUDDEN CYN	3	Intermittent stream
YNEZ AT 35TH ST.	2	Lagoon
YNEZ ABOVE LAGOON	2	Lagoon, lower river
YNEZ AT 13TH ST.	2	Shallow river
YNEZ WATER TRMT PLT	2	Shallow river
WATER CYN	3	Intermittent stream

TABLE 2. Survey effort and trapping time for sites studied at Vandenberg Air Force Base in 1995. Sites in Column One are described in Table . Survey time is given in person-minutes (product of the number of minutes surveyed and the number of observers) for visual (wading) surveys, boat-aided visual surveys, and net-aided surveys. Trap time is the product of the number of traps and the total minutes set.

Site	No. visits	Day visual	Day boat	Night visual	Night boat	Dip net	Seine	Tadpole traps	Turtle traps
1	1	10	0	0	0	0	0	0	0
2	2	15	0	10	0	0	0	0	0
3	1	0	0	0	0	0	0	0	0
4	4	80	0	10	0	0	0	0	0
5	3	74	0	0	0	0	0	0	0
6	2	0	0	0	0	0	0	0	0
7	3	69	0	0	0	0	0	0	0
8	1	15	0	0	0	0	0	0	0
9	3	15	0	13	0	0	0	0	0
10	1	10	0	0	0	0	0	0	0
11	2	17	0	0	0	0	0	0	0
12	2	10	0	0	0	0	0	0	0
13	2	10	0	8	0	0	0	0	0
14	4	172	0	64	0	81	51	100	0
15	3	10	0	10	0	15	0	0	0
16	2	45	0	15	0	0	0	0	0
17	11	5	50	52	0	0	0	3840	15480
18	7	515	0	140	0	115	90	2244	0
19	2	46	0	0	0	0	0	0	0
20	2	35	0	0	0	0	0	0	0
21	2	5	0	20	0	0	0	0	0
22	1	0	0	0	0	0	0	0	0
23	1	0	0	0	0	0	0	0	0
24	3	18	0	0	0	13	0	2900	0
25	2	3	0	0	0	0	0	0	0
26	11	154	0	89	0	25	0	0	0
27	10	918	70	290	0	0	0	23808	6700
28	5	108	0	0	0	0	20	0	0
29	7	110	35	62	0	20	0	3840	0

This was trapped

TABLE 2. Continued.

Site	No. visits	Day visual	Day boat	Night visual	Night boat	Dip net	Seine	Tadpole traps	Turtle traps
30	16	439	18	474	0	0	0	8160	0
31	6	192	0	64	0	86	1	2400	0
32	2	28	0	0	0	14	1	0	0
33	1	0	0	10	0	0	0	0	0
34	8	116	0	186	0	81	1	24480	0
35	5	110	0	28	0	55	1	12120	0
36	8	35	60	416	0	0	0	2720	0
37	9	146	0	321	0	73	1	11520	38160
38	10	235	75	170	45	0	0	1944	57360
39	11	495	83	135	0	105	1	0	47640
40	3	65	0	46	0	45	2	0	0
41	7	130	0	40	80	10	1	0	12240
42	5	60	0	58	0	30	1	1800	0
43	1	30	0	0	0	15	1	0	0
44	3	71	0	34	0	33	1	0	0
45	13	250	20	646	460	0	0	6060	120840
46	12	365	20	401	120	110	55	6240	31320
47	10	109	47	201	0	48	46	0	15640
48	2	70	0	56	0	0	0	0	0
49	2	40	0	0	0	0	0	0	0
50	1	0	0	0	0	0	0	0	0
51	2	43	0	0	0	33	1	0	0
52	5	90	0	26	0	0	20	2880	0
53	3	76	0	40	0	0	30	2936	0
54	2	45	0	0	0	15	0	0	0
55	1	31	0	0	0	12	0	0	0
56	1	75	0	0	0	30	0	0	0
57	1	55	0	0	0	20	0	0	0
58	8	130	0	100	0	40	0	2520	32880
59	3	105	0	50	0	105	0	2560	0
60	4	172	180	0	0	0	0	0	17380

TABLE 2. Continued.

Site	No. visits	Day visual	Day boat	Night visual	Night boat	Dip net	Seine	Tadpole traps	Turtle traps
61	5	100	250	58	48	0	0	3480	11400
62	4	0	0	66	0	0	0	2600	0
63	8	135	0	86	0	5	0	8152	0
64	2	10	0	0	0	10	0	660	0
65	3	115	0	0	0	10	0	2840	0
66	5	35	70	114	0	0	0	2240	0
67	5	15	0	108	0	0	0	3144	0
68	6	100	0	80	0	35	0	1768	0
69	2	0	0	10	0	0	0	0	0
70	2	0	0	8	0	0	0	0	0
71	3	76	60	76	0	0	35	0	0
72	3	99	60	106	0	0	33	0	0
73	4	280	0	154	0	0	0	9800	7350
74	2	5	0	26	0	0	0	0	0
75	3	110	0	80	0	0	0	2720	0
76	3	70	0	90	0	0	0	2640	0
77	4	45	45	107	55	0	0	3680	0
78	4	130	0	148	0	0	0	3456	0
79	3	100	0	60	0	0	0	3440	0
80	2	100	0	54	0	0	0	3840	0
81	2	100	0	71	71	0	0	3184	0
82	2	25	0	20	0	0	0	0	0
83	1	60	0	0	0	0	0	0	0
84	2	20	0	0	0	0	0	0	0
85	2	90	0	60	0	0	0	2520	0
86	1	30	0	0	0	0	0	0	0
87	1	0	0	40	0	0	0	0	0
88	1	10	0	0	0	0	0	0	0

TABLE 2. Continued.

Site	No. visits	Day visual	Day boat	Night visual	Night boat	Dip net	Seine	Tadpole traps	Turtle traps
ANTONIO LAGOON	2	94	0	200	0	0	0	0	0
ANTONIO AT SPRR	4	0	160	220	220	0	0	11160	5580
ANTONIO TURTLE MARSH	2	70	0	0	0	0	0	0	0
ANTONIO AT EL RANCHO	13	260	0	137	0	0	0	1760	2460
ANTONIO MARSH S TRIB	1	0	0	12	0	0	0	0	0
ANTONIO AT L-C RD.	8	153	0	171	0	0	0	2160	8820
ANTONIO RD. W	1	346	0	6	0	346	0	0	0
ANTONIO AT RECYC CTR	4	45	0	40	0	0	0	0	0
ANTONIO AT STATE WATER	3	80	0	50	0	0	0	2160	0
ANTONIO AT HWY. 1	2	65	0	330	0	65	0	0	0
BEAR VALLEY	5	160	0	150	0	0	0	0	0
CANADA DE LAS LADRONES	1	30	0	0	0	0	0	0	0
CREEK E OF JOLLORU	1	20	0	0	0	0	0	0	0
DITCH 13TH ST	2	16	0	0	0	0	0	0	0
EL RANCHO ERODED	1	9	0	0	0	3	0	0	0
HONDA LAGOON-COAST RD		635	0	190	0	263	0	2880	0
HONDA CYN RD 1-3 XING	2	160	0	240	0	160	0	0	0
HONDA AT POWER LINE	7	290	0	110	0	0	0	0	8460
HONDA TRANQ. MTN RD.	4	195	0	174	0	0	0	0	0
HONDA AT E BASE BDY.	5	267	0	106	0	0	0	2304	0
JALAMA LAGOON-SPRR	13	563	0	304	0	130	0	1440	4440
JOLLORU	3	30	0	44	0	0	0	0	0
LOMPOC CYN	4	124	0	10	0	0	0	0	0
LONG HORN CYN	1	30	0	0	0	0	0	0	0
OCEAN AVE DITCH	3	100	0	90	0	0	0	0	0
OIL WELL CYN	1	10	0	0	0	0	0	0	0
NEAR PT SAL	2	90	0	150	0	0	0	0	0
SHUMAN LAGOON	3	294	80	115	115	0	35	0	0
SHUMAN AT PT SAL RD	4	60	0	50	0	0	0	0	0
CASMALIA/SHUMAN	2	90	0	90	0	0	0	0	0

I think this
is wrong

TABLE 2. Continued.

Site	No. visits	Day visual	Day boat	Night visual	Night boat	Dip net	Seine	Tadpole traps	Turtle traps
SUDDEN CYN	1	70	0	0	0	0	0	0	0
YNEZ AT 35TH	2	20	0	14	0	0	0	0	0
YNEZ ABOVE LAGOON	3	0	0	694	180	120	0	1040	260
YNEZ AT 13TH ST.	10	565	0	462	0	0	0	0	0
YNEZ WATER TRMT PLT	3	30	0	290	0	0	0	0	0
WATER CYN	1	40	0	0	0	0	0	0	0

Table 3. Amphibian and reptile species encountered during 1995 field investigations on Vandenberg Air Force Base, California. Nomenclature follows J. T. Collins (1990) unless noted.

Caudata	
<i>Aneides lugubris</i>	Arboreal Salamander
<i>Batrachoseps nigriventris</i>	Blackbelly Slender Salamander
<i>Ensatina eschscholtzii</i>	Ensatina
Salientia	
<i>Bufo boreas</i>	Western Toad
<i>Pseudacris regilla</i>	Pacific Chorus Frog
<i>Rana aurora</i>	Red-legged Frog
<i>Rana catesbeiana</i>	Bullfrog
<i>Spea hammondi</i>	Western Spadefoot
Testudines	
<i>Clemmys marmorata</i>	Western Pond Turtle
<i>Trachemys scripta</i>	Slider
Lacertilia	
<i>Anniella pulchra</i> ¹	California Legless Lizard
<i>Elgaria multicarinata</i>	Southern Alligator Lizard
<i>Eumeces skiltonianus</i>	Western Skink
<i>Phrynosoma coronatum</i>	Coast Horned Lizard
<i>Sceloporus occidentalis</i>	Western Fence Lizard
<i>Uta stansburiana</i>	Side-blotched Lizard
Serpentes	
<i>Coluber constrictor</i>	Racer
<i>Crotalus viridis</i>	Western Rattlesnake
<i>Lampropeltis getula</i>	Common Kingsnake
<i>Masticophis lateralis</i>	Striped Racer
<i>Pituophis melanoleucus</i>	Gopher Snake
<i>Thamnophis elegans</i>	Western Terrestrial Garter Snake
<i>Thamnophis hammondi</i>	Two-striped Garter Snake
<i>Thamnophis sirtalis</i>	Common Garter Snake

¹Nomenclature follows Murphy and Smith (1991).

TABLE 4. Abundance of western spadefoot toads (*Spea hammondi*), two-striped garter snakes (*Thamnophis hammondi*), and western pond turtles (*Clemmys marmorata*) at Vandenberg Air Force Base, California in 1995. Sites in Column One are described in Table 1. Totals represent the sum of observations for all surveys, including visual surveys and those caught in tadpole and turtle traps. If an area was surveyed more than once, the same individual may have been counted more than once, and the total value would not accurately reflect the relative number present. Therefore, maximum number of individuals is a better measure of abundance since individuals were not counted more than once. If more than one identical survey was performed at a site, the mean number of individuals observed is given. Blanks in the mean columns indicate that if more than one survey was performed the survey technique was not identical.

Site	Total adult toads	Max adult toads	Mean adult toads	Total calling toads	Max calling toads	Total toad tadpoles	Total snakes	Max snakes	Mean snakes	Total turtles	Max turtles
4	0	0	0.00	0	0	0	0	0	0.00	0	0
5	0	0	0.00	0	0	0	0	0	0.00	0	0
7	0	0	0.00	0	0	0	0	0	0.00	0	0
9	0	0	0.00	0	0	0	0	0	0.00	0	0
12	0	0	0.00	0	0	0	0	0	0.00	0	0
14	0	0	0.00	0	0	0	0	0	0.00	0	0
16	0	0	0.00	0	0	0	0	0	0.00	0	0
17	0	0	0.00	0	0	0	0	0	0.00	0	0
18	6	5	2.50	8	8	21	0	0	0.00	0	0
19	0	0	0.00	0	0	0	0	0	0.00	0	0
21	0	0	0.00	0	0	0	0	0	0.00	0	0
26	0	0	0.00	0	0	0	0	0	0.00	0	0
27	0	0	0.00	0	0	0	0	0	0.00	0	0
28	0	0	0.00	0	0	0	0	0	0.00	0	0
29	0	0	0.00	0	0	0	0	0	0.00	0	0
30	0	0	0.00	0	0	0	0	0	0.00	0	0
31	0	0	0.00	0	0	0	0	0	0.00	0	0
34	2	1	0.67	8	5	1	0	0	0.00	0	0
35	0	0	0.00	0	0	0	0	0	0.00	0	0
36	0	0	0.00	0	0	0	0	0	0.00	0	0
37	0	0	0.00	0	0	0	0	0	0.00	2	1
38	0	0	0.00	0	0	0	0	0	0.00	1	1
39	0	0	0.00	0	0	0	0	0	0.00	1	1
40	0	0	0.00	0	0	0	0	0	0.00	0	0
41	0	0	0.00	0	0	0	0	0	0.00	0	0
42	0	0	0.00	0	0	0	0	0	0.00	0	0

TABLE 4. Continued.

Site	Total adult toads	Max adult toads	Mean adult toads	Total calling toads	Max calling toads	Total toad tadpoles	Total snakes	Max snakes	Mean snakes	Total turtles	Max turtles
44	0	0	0.00	0	0	0	0	0	0.00	0	0
45	0	0	0.00	0	0	0	0	0	0.00	27	12
46	0	0	0.00	0	0	0	0	0	0.00	59	51
47	0	0	0.00	0	0	0	0	0	0.00	0	0
48	0	0	0.00	0	0	0	0	0	0.00	0	0
49	0	0	0.00	0	0	0	0	0	0.00	0	0
51	0	0	0.00	0	0	3	0	0	0.00	0	0
52	0	0	0.00	0	0	0	0	0	0.00	0	0
53	0	0	0.00	0	0	0	0	0	0.00	0	0
57	0	0	0.00	0	0	0	0	0	0.00	0	0
58	0	0	0.00	0	0	0	0	0	0.00	5	5
59	0	0	0.00	0	0	4	0	0	0.00	0	0
60	0	0	0.00	0	0	0	0	0	0.00	1	1
61	0	0	0.00	0	0	0	0	0	0.00	7	5
63	0	0	0.00	0	0	0	0	0	0.00	0	0
65	0	0	0.00	0	0	0	0	0	0.00	0	0
66	0	0	0.00	0	0	0	0	0	0.00	0	0
67	0	0	0.00	0	0	0	0	0	0.00	0	0
68	0	0	0.00	0	0	0	0	0	0.00	0	0
71	0	0	0.00	0	0	0	0	0	0.00	0	0
72	0	0	0.00	0	0	0	0	0	0.00	0	0
73	0	0	0.00	0	0	0	0	0	0.00	0	0
74	0	0	0.00	0	0	0	0	0	0.00	0	0
75	0	0	0.00	0	0	0	0	0	0.00	0	0
76	0	0	0.00	0	0	0	0	0	0.00	0	0
77	0	0	0.00	0	0	0	0	0	0.00	0	0
78	0	0	0.00	0	0	0	0	0	0.00	0	0
79	0	0	0.00	0	0	0	0	0	0.00	0	0
80	0	0	0.00	0	0	0	0	0	0.00	0	0
81	0	0	0.00	0	0	0	0	0	0.00	0	0
83	0	0	0.00	0	0	0	0	0	0.00	1	1
85	0	0	0.00	0	0	0	0	0	0.00	0	0
87	0	0	0.00	0	0	0	0	0	0.00	0	0

TABLE 4. Continued.

Site	Total adult toads	Max adult toads	Mean adult toads	Total calling toads	Max calling toads	Total toad tadpoles	Total snakes	Max snakes	Mean snakes	Total turtles	Max turtles
ANTONIO AT EL RANCHO	0	0	0.00	0	0	0	0	0	0.00	0	0
ANTONIO AT L-C RD.	0	0	0.00	0	0	0	0	0	0.00	1	1
ANTONIO AT RECYC CTR	0	0	0.00	0	0	0	0	0	0.00	0	0
ANTONIO AT SPRR	0	0	0.00	0	0	0	0	0	0.00	0	0
ANTONIO AT HWY. 1	0	0	0.00	0	0	0	1	1		1	1
ANTONIO RD. W	0	0	0.00	0	0	0	1	1		3	3
ANTONIO LAGOON	0	0	0.00	0	0	0	0	0	0.00	0	0
ANTONIO MARSH S TRIB	0	0	0.00	0	0	0	0	0	0.00	0	0
ANTONIO TURTLE MARSH	0	0	0.00	0	0	0	0	0	0.00	0	0
ANTONIO AT STATE WATER	0	0	0.00	0	0	0	0	0	0.00	0	0
BEAR VALLEY	0	0	0.00	0	0	0	0	0	0.00	0	0
CASMALIA/SHUMAN	0	0	0.00	0	0	0	0	0	0.00	0	0
HONDA TRANQ. MTN RD.	0	0	0.00	0	0	0	1	1	0.50	1	1
HONDA BELOW POWER LINE	0	0	0.00	0	0	0	3	3	1.50	4	4
HONDA LAGOON-COAST RD	0	0	0.00	0	0	0	3	1	0.50	0	0
HONDA E BASE BDY	0	0	0.00	0	0	0	0	0	0.00	0	0
HONDA CYN RD 1-3 XING	0	0	0.00	0	0	0	4	4		0	0
JALAMA LAGOON-SPRR	0	0	0.00	0	0	0	1	1		30	18
JOLLORU	0	0	0.00	0	0	0	0	0	0.00	0	0
NEAR PT SAL	0	0	0.00	0	0	0	0	0	0.00	0	0
OCEAN AVE DITCH	0	0	0.00	0	0	0	0	0	0.00	0	0
SHUMAN LAGOON	0	0	0.00	0	0	0	0	0	0.00	0	0
YNEZ AT 13TH ST.	0	0	0.00	0	0	0	0	0	0.00	0	0
YNEZ ABOVE LAGOON	0	0	0.00	0	0	0	0	0	0.00	0	0
YNEZ WATER TRMT PLT	0	0	0.00	0	0	0	0	0	0.00	0	0
YNEZ AT 35TH	0	0	0.00	0	0	0	0	0	0.00	0	0

TABLE 5. Abundance of California red-legged frogs (*Rana aurora draytonii*) at Vandenberg Air Force Base, California in 1995. Sites in Column One are described in Table 1. Totals represent the sum of observations for all surveys, including visual surveys and those caught in tadpole and turtle traps. If an area was surveyed more than once, the same individual may have been counted more than once, and the total value would not accurately reflect the relative number present. Therefore, maximum number of individuals is a better measure of abundance since individuals were not counted more than once. If more than one identical survey was performed at a site, the mean number of individuals observed is given. Blanks in the mean columns indicate that if more than one survey was performed the survey technique was not identical.

Site	Total adults	Max adults	Mean adults	Total calling	Max calling	Total metamorphs	Max metamorphs	Mean metamorphs	Total tadpoles	Total eggs
4	0	0	0.00	0	0	0	0	0.00	0	0
5	0	0	0.00	0	0	0	0	0.00	0	0
7	0	0	0.00	0	0	0	0	0.00	0	0
9	0	0	0.00	0	0	0	0	0.00	0	0
12	0	0	0.00	0	0	0	0	0.00	0	0
14	0	0	0.00	0	0	0	0	0.00	0	0
16	0	0	0.00	0	0	0	0	0.00	0	0
17	9	6		0	0	0	0	0.00	0	0
18	0	0	0.00	0	0	0	0	0.00	0	0
19	0	0	0.00	0	0	0	0	0.00	0	0
21	0	0	0.00	0	0	0	0	0.00	0	0
26	4	4		5	5	0	0	0.00	3	1
27	5	5	1.67	5	5	11	10	3.67	60	4
28	0	0	0.00	0	0	0	0	0.00	0	0
29	4	4		0	0	0	0	0.00	0	0
30	6	4	1.33	2	2	0	0	0.00	2	0
31	0	0	0.00	0	0	0	0	0.00	0	0
34	0	0	0.00	0	0	0	0	0.00	0	0
35	0	0	0.00	0	0	0	0	0.00	0	0
36	7	3	2.33	3	3	0	0	0.00	0	0
37	0	0	0.00	2	2	0	0	0.00	0	0
38	4	3	2.00	0	0	1	1	1.00	0	0
39	6	3	2.50	6	5	16	9	4.00	26	5
40	0	0	0.00	0	0	0	0	0.00	0	0
41	0	0	0.00	0	0	0	0	0.00	0	0
42	0	0	0.00	0	0	0	0	0.00	0	0

TABLE 5. Continued.

Site	Total adults	Max adults	Mean adults	Total calling	Max calling	Total metamorphs	Max metamorphs	Mean metamorphs	Total tadpoles	Total eggs
44	0	0	0.00	0	0	0	0	0.00	0	0
45	0	0	0.00	0	0	0	0	0.00	0	0
46	0	0	0.00	4	3	0	0	0.00	0	0
47	11	4	2.20	0	0	0	0	0.00	34	0
48	0	0	0.00	0	0	0	0	0.00	0	0
49	0	0	0.00	0	0	0	0	0.00	0	0
51	0	0	0.00	0	0	0	0	0.00	0	0
52	0	0	0.00	0	0	0	0	0.00	0	0
53	0	0	0.00	0	0	0	0	0.00	0	0
57	0	0	0.00	0	0	0	0	0.00	0	0
58	0	0	0.00	0	0	0	0	0.00	0	0
59	0	0	0.00	0	0	0	0	0.00	0	0
60	2	2		0	0	90	39	12.50	86	0
61	2	2		0	0	0	0	0.00	0	0
63	0	0	0.00	0	0	24	12	7.33	1	0
65	0	0	0.00	0	0	0	0	0.00	0	0
66	0	0	0.00	0	0	0	0	0.00	0	0
67	0	0	0.00	0	0	0	0	0.00	0	0
68	0	0	0.00	0	0	0	0	0.00	0	0
71	11	11		0	0	0	0	0.00	0	0
72	1	1		0	0	0	0	0.00	0	0
73	10	7	5.00	0	0	0	0	0.00	4	0
74	0	0	0.00	0	0	0	0	0.00	0	0
75	1	1		0	0	0	0	0.00	1	0
76	4	4		0	0	0	0	0.00	0	0
77	7	6	3.50	0	0	0	0	0.00	0	0
78	22	15	11.00	0	0	0	0	0.00	0	0
79	0	0	0.00	0	0	0	0	0.00	0	0
80	0	0	0.00	0	0	0	0	0.00	0	0
81	3	3		0	0	0	0	0.00	0	0
83	0	0	0.00	0	0	1	1		0	0
85	0	0	0.00	0	0	4	4		4	0
87	2	2		0	0	30	30		0	0

TABLE 5. Continued.

Site	Total adults	Max adults	Mean adults	Total calling	Max calling	Total metamorphs	Max metamorphs	Mean metamorphs	Total tadpoles	Total eggs
ANTONIO AT EL RANCHO	25	10	5.00	7	5	0	0	0.00	0	9
ANTONIO AT L-C RD.	11	5	2.75	0	0	0	0	0.00	0	0
ANTONIO AT RECYC CTR	0	0	0.00	0	0	0	0	0.00	0	0
ANTONIO AT SPRR	11	6	5.50	0	0	0	0	0.00	0	0
ANTONIO AT HWY. 1	9	9		0	0	0	0	0.00	0	0
ANTONIO RD. W	0	0	0.00	0	0	0	0	0.00	0	0
ANTONIO LAGOON	28	24		0	0	0	0	0.00	1	0
ANTONIO MARSH S TRIB	2	2		0	0	0	0	0.00	0	0
ANTONIO TURTLE MARSH	0	0	0.00	0	0	0	0	0.00	0	0
ANTONIO AT STATE WATER	0	0	0.00	0	0	0	0	0.00	0	0
BEAR VALLEY	0	0	0.00	0	0	0	0	0.00	0	0
CASMALIA/SHUMAN	1	1		0	0	0	0	0.00	0	0
HONDA TRANQ. MTN RD.	1	1	0.50	0	0	0	0	0.00	0	0
HONDA BELOW POWER LINE	0	0	0.00	0	0	0	0	0.00	0	0
HONDA LAGOON-COAST RD	8	8		0	0	6	6	2.00	1	0
HONDA E BASE BDY	0	0	0.00	0	0	0	0	0.00	0	0
HONDA CYN RD 1-3 XING	1	1		0	0	21	16		0	0
JALAMA LAGOON-SPRR	18	18		0	0	1	1		200	0
JOLLORU	0	0	0.00	0	0	0	0	0.00	0	0
NEAR PT SAL	1	1		0	0	0	0	0.00	0	0
OCEAN AVE DITCH	1	1		0	0	0	0	0.00	0	0
SHUMAN LAGOON	6	5		0	0	0	0	0.00	4	0
YNEZ AT 13TH ST.	0	0	0.00	0	0	0	0	0.00	0	0
YNEZ ABOVE LAGOON	9	7	4.50	0	0	0	0	0.00	0	0
YNEZ WATER TRMT PLT	1	1		0	0	0	0	0.00	0	0
YNEZ AT 35TH	0	0	0.00	0	0	0	0	0.00	0	0

TABLE 6. Abundance of bullfrogs (*Rana catesbeiana*) at Vandenberg Air Force Base, California in 1995. Sites in Column One are described in Table 1. Totals represent the sum of observations for all surveys, including visual surveys and those caught in tadpole and turtle traps. If an area was surveyed more than once, the same individual may have been counted more than once, and the total value would not accurately reflect the relative number present. Therefore, maximum number of individuals is a better measure of abundance since individuals were not counted more than once. If more than one identical survey was performed at a site, the mean number of individuals observed is given. Blanks in the mean columns indicate that if more than one survey was performed the survey technique was not identical.

Site	Total adults	Max adults	Mean adults	Total calling	Max calling	Total metamorphs	Max metamorphs	Mean metamorphs	Total tadpoles
4	0	0	0.00	0	0	0	0	0.00	0
5	0	0	0.00	0	0	0	0	0.00	0
7	0	0	0.00	0	0	0	0	0.00	0
9	0	0	0.00	0	0	0	0	0.00	0
12	0	0	0.00	0	0	0	0	0.00	0
14	0	0	0.00	0	0	0	0	0.00	0
16	0	0	0.00	0	0	0	0	0.00	0
17	0	0	0.00	0	0	0	0	0.00	0
18	0	0	0.00	0	0	0	0	0.00	0
19	0	0	0.00	0	0	0	0	0.00	0
21	0	0	0.00	0	0	0	0	0.00	0
26	0	0	0.00	0	0	0	0	0.00	0
27	0	0	0.00	0	0	0	0	0.00	0
28	0	0	0.00	0	0	0	0	0.00	0
29	0	0	0.00	0	0	0	0	0.00	0
30	8	3	2.50	0	0	0	0	0.00	0
31	0	0	0.00	0	0	0	0	0.00	0
34	0	0	0.00	0	0	0	0	0.00	0
35	0	0	0.00	0	0	0	0	0.00	0
36	16	11	8.00	0	0	0	0	0.00	0
37	0	0	0.00	0	0	0	0	0.00	0
38	0	0	0.00	1	1	0	0	0.00	0
39	0	0	0.00	1	1	0	0	0.00	0
40	0	0	0.00	0	0	0	0	0.00	0
41	0	0	0.00	0	0	0	0	0.00	0
42	0	0	0.00	0	0	0	0	0.00	0
44	0	0	0.00	0	0	0	0	0.00	0
45	41	16	6.83	8	8	2	1	0.67	6

TABLE 6. Continued.

Site	Total adults	Max adults	Mean adults	Total calling	Max calling	Total metamorphs	Max metamorphs	Mean metamorphs	Total tadpoles
46	0	0	0.00	4	4	0	0	0.00	0
47	0	0	0.00	0	0	0	0	0.00	0
48	12	12		1	1	0	0	0.00	0
49	0	0	0.00	0	0	0	0	0.00	0
51	0	0	0.00	0	0	0	0	0.00	0
52	0	0	0.00	0	0	0	0	0.00	0
53	0	0	0.00	0	0	0	0	0.00	0
57	0	0	0.00	0	0	0	0	0.00	0
58	0	0	0.00	0	0	0	0	0.00	0
59	0	0	0.00	0	0	0	0	0.00	0
60	0	0	0.00	0	0	0	0	0.00	0
61	0	0	0.00	1	1	0	0	0.00	0
63	0	0	0.00	0	0	0	0	0.00	0
65	0	0	0.00	0	0	0	0	0.00	0
66	2	1	1.00	0	0	0	0	0.00	0
67	3	3		0	0	0	0	0.00	0
68	2			0	0	0	0	0.00	0
71	0	0	0.00	0	0	0	0	0.00	0
72	0	0	0.00	0	0	0	0	0.00	0
73	0	0	0.00	0	0	0	0	0.00	0
74	0	0	0.00	0	0	0	0	0.00	0
75	0	0	0.00	0	0	0	0	0.00	0
76	0	0	0.00	0	0	0	0	0.00	0
77	0	0	0.00	0	0	0	0	0.00	0
78	0	0	0.00	0	0	0	0	0.00	0
79	0	0	0.00	0	0	0	0	0.00	0
80	0	0	0.00	0	0	0	0	0.00	0
81	0	0	0.00	0	0	0	0	0.00	0
83	1	1		0	0	0	0	0.00	0
85	0	0	0.00	0	0	0	0	0.00	0
87	0	0	0.00	0	0	0	0	0.00	0

TABLE 6. Continued.

Site	Total adults	Max adults	Mean adults	Total calling	Max calling	Total metamorphs	Max metamorphs	Mean metamorphs	Total tadpoles
ANTONIO AT EL RANCHO	0	0	0.00	0	0	0	0	0.00	0
ANTONIO AT L-C RD.	6	2	2.00	0	0	0	0	0.00	0
ANTONIO AT RECYC CTR	1	1	0.50	0	0	0	0	0.00	0
ANTONIO AT SPRR	0	0	0.00	0	0	0	0	0.00	0
ANTONIO AT HWY. 1	4	3		0	0	0	0	0.00	0
ANTONIO RD. W	1	1		0	0	0	0	0.00	0
ANTONIO LAGOON	0	0	0.00	0	0	0	0	0.00	0
ANTONIO MARSH S TRIB	0	0	0.00	0	0	0	0	0.00	0
ANTONIO TURTLE MARSH	0	0	0.00	0	0	0	0	0.00	0
ANTONIO AT STATE WATER	1	1		0	0	0	0	0.00	0
BEAR VALLEY	0	0	0.00	0	0	0	0	0.00	0
CASMALIA/SHUMAN	0	0	0.00	0	0	0	0	0.00	0
HONDA TRANQ. MTN RD.	0	0	0.00	0	0	0	0	0.00	0
HONDA BELOW POWER LINE	0	0	0.00	0	0	0	0	0.00	0
HONDA LAGOON-COAST RD	0	0	0.00	0	0	0	0	0.00	0
HONDA E BASE BDY	0	0	0.00	0	0	0	0	0.00	0
HONDA CYN RD 1-3 XING	0	0	0.00	0	0	0	0	0.00	0
JALAMA LAGOON-SPRR	0	0	0.00	0	0	0	0	0.00	0
JOLLORU	0	0	0.00	0	0	0	0	0.00	0
NEAR PT SAL	0	0	0.00	0	0	0	0	0.00	0
OCEAN AVE DITCH	0	0	0.00	0	0	0	0	0.00	0
SHUMAN LAGOON	0	0	0.00	0	0	0	0	0.00	0
YNEZ AT 13TH ST.	13	12		0	0	0	0	0.00	0
YNEZ ABOVE LAGOON	13	7	6.50	2	2	8	4	4.00	0
YNEZ WATER TRMT PLT	7	7		0	0	0	0	0.00	0
YNEZ AT 35TH	0	0	0.00	0	0	0	0	0.00	0

TABLE 7. Abundance of western toads (*Bufo boreas*) and Pacific chorus frogs (*Pseudacris regilla*) at Vandenberg Air Force Base, California in 1995. Sites in Column One are described in Table 1. Totals represent the sum of observations for all surveys, including visual surveys and those caught in tadpole and turtle traps. If an area was surveyed more than once, the same individual may have been counted more than once, and the total value would not accurately reflect the relative number present. Therefore, maximum number of individuals is a better measure of abundance since individuals were not counted more than once. If more than one identical survey was performed at a site, the mean number of individuals observed is given. Blanks in the mean columns indicate that if more than one survey was performed the survey technique was not identical.

Site	Total adult toads	Max adult toads	Mean adult toads	Total toad metamorphs	Max toad metamorphs	Ave. toad metamorphs	Total toad tadpoles	Total adult treefrogs	Max adult treefrogs	Mean adult treefrogs	Total treefrog metamorphs	Max treefrog metamorphs	Mean treefrog metamorphs
4	0	0	0.00	0	0	0.00	0	10	10	5.00	0	0	0.00
5	0	0	0.00	0	0	0.00	0	7	7		0	0	0.00
7	0	0	0.00	0	0	0.00	0	15	15		0	0	0.00
9	0	0	0.00	0	0	0.00	0	2	2		0	0	0.00
12	0	0	0.00	0	0	0.00	0	10	10		0	0	0.00
14	0	0	0.00	0	0	0.00	0	37	17		1	1	
16	0	0	0.00	0	0	0.00	0	12	12		0	0	0.00
17	0	0	0.00	0	0	0.00	0	11	11		0	0	0.00
18	13	8	6.50	1	1		160	16	7	5.50	1	1	
19	0	0	0.00	0	0	0.00	0	1	1		0	0	0.00
21	0	0	0.00	0	0	0.00	0	1	1		0	0	0.00
26	1	1		0	0	0.00	5000	0	0	0.00	0	0	0.00
27	0	0	0.00	0	0	0.00	0	6	5	2.00	6	4	2.00
28	0	0	0.00	0	0	0.00	12	6	6		0	0	0.00
29	0	0	0.00	0	0	0.00	0	3	2		5	5	
30	0	0	0.00	0	0	0.00	0	15	8	1.67	137	66	27.40
31	0	0	0.00	0	0	0.00	0	1	1	0.50	40	40	20.00
34	0	0	0.00	0	0	0.00	80	11	5	3.67	0	0	0.00
35	0	0	0.00	0	0	0.00	320	0	0	0.00	0	0	0.00
36	0	0	0.00	0	0	0.00	0	0	0	0.00	2	2	
37	0	0	0.00	0	0	0.00	0	1	1		0	0	0.00
38	0	0	0.00	0	0	0.00	0	0	0	0.00	0	0	0.00
39	0	0	0.00	0	0	0.00	0	2	2	1.00	1	1	0.20
40	0	0	0.00	0	0	0.00	80	1	1		0	0	0.00
41	3	2	1.50	0	0	0.00	200	0	0	0.00	0	0	0.00
42	0	0	0.00	0	0	0.00	0	3	2	1.50	3	3	1.50

TABLE 7. Continued.

Site	Total adult toads	Max adult toads	Mean adult toads	Total toad metamorphs	Max toad metamorphs	Mean toad metamorphs	Total toad tadpoles	Total adult treefrogs	Max adult treefrogs	Mean adult treefrogs	Total treefrog metamorphs	Max treefrog metamorphs	Mean treefrog metamorphs
44	2	2		0	0	0.00	320	19	19		0	0	0.00
45	1	1	0.17	0	0	0.00	0	0	0	0.00	0	0	0.00
46	2	1		0	0	0.00	0	1	1		0	0	0.00
47	0	0	0.00	0	0	0.00	0	1	1	0.25	1	1	0.25
48	0	0	0.00	0	0	0.00	0	0	0	0.00	0	0	0.00
49	0	0	0.00	0	0	0.00	0	0	0	0.00	1	1	
51	0	0	0.00	0	0	0.00	0	0	0	0.00	0	0	0.00
52	0	0	0.00	0	0	0.00	0	0	0	0.00	21	16	
53	0	0	0.00	0	0	0.00	5	0	0	0.00	13	10	
57	0	0	0.00	0	0	0.00	0	1	1		0	0	0.00
58	0	0	0.00	0	0	0.00	0	1	1		1	1	
59	0	0	0.00	0	0	0.00	0	3	3		12	12	
60	0	0	0.00	0	0	0.00	0	0	0	0.00	2	1	0.50
61	0	0	0.00	0	0	0.00	0	4	4		1		
63	0	0	0.00	0	0	0.00	0	0	0	0.00	11	5	1.83
65	0	0	0.00	0	0	0.00	0	1	1		0		
66	0	0	0.00	0	0	0.00	0	1	1	0.50	20	11	4.50
67	1	1		0	0	0.00	0	1	1		1	1	
68	0	0	0.00	0	0	0.00	0	0	0	0.00	0	0	0.00
71	0	0	0.00	0	0	0.00	0	7	7		2	2	
72	0	0	0.00	0	0	0.00	0	11	11		20	20	
73	0	0	0.00	0	0	0.00	0	1	1	0.50	2	2	0.50
74	0	0	0.00	1	1		0	0	0	0.00	133	130	
75	0	0	0.00	0	0	0.00	0	0	0	0.00	0	0	0.00
76	1	1		0	0	0.00	0	0	0	0.00	9	7	
77	0	0	0.00	0	0	0.00	0	1	1	0.50	1	1	0.50
78	0	0	0.00	0	0	0.00	0	0	0	0.00	3	2	1.50
79	0	0	0.00	0	0	0.00	0	8	6		0	0	0.00
80	0	0	0.00	50	50		0	0	0	0.00	10	5	
81	0	0	0.00	0	0	0.00	0	2	2		0	0	0.00
83	0	0	0.00	0	0	0.00	0	0	0	0.00	0	0	0.00
85	0	0	0.00	0	0	0.00	0	0	0	0.00	100	100	
87	0	0	0.00	1	1		0	0	0	0.00	0	0	0.00

TABLE 7. Continued.

Site	Total adult toads	Max adult toads	Mean adult toads	Total toad metamorphs	Max toad metamorphs	Mean toad metamorphs	Total toad tadpoles	Total adult treefrogs	Max adult treefrogs	Mean adult treefrogs	Total treefrog metamorphs	Max treefrog metamorphs	Mean treefrog metamorphs
ANTONIO AT EL RANCHO	0	0	0.00	0	0	0.00	0	5	2		0	0	0.00
ANTONIO AT L-C RD.	0	0	0.00	0	0	0.00	0	0	0	0.00	1	1	
ANTONIO AT RECYC CTR	0	0	0.00	0	0	0.00	0	0	0	0.00	0	0	0.00
ANTONIO AT SPRR	0	0	0.00	0	0	0.00	0	0	0	0.00	1	1	
ANTONIO AT HWY. 1	0	0	0.00	0	0	0.00	0	0	0	0.00	0	0	0.00
ANTONIO RD. W	0	0	0.00	0	0	0.00	0	0	0	0.00	0	0	0.00
ANTONIO LAGOON	0	0	0.00	0	0	0.00	0	13	12		0	0	0.00
ANTONIO MARSH S TRIB	0	0	0.00	0	0	0.00	0	0	0	0.00	0	0	0.00
ANTONIO TURTLE MARSH	0	0	0.00	0	0	0.00	0	0	0	0.00	15	15	
ANTONIO AT STATE WATER	0	0	0.00	0	0	0.00	0	0	0	0.00	0	0	0.00
BEAR VALLEY	0	0	0.00	0	0	0.00	0	6	6	3.00	60	60	30.00
CASMALIA/ SHUMAN	0	0	0.00	0	0	0.00	0	1	1		21	20	
HONDA TRANQ. MTN RD.	0	0	0.00	0	0	0.00	0	1	1		18	15	4.50
HONDA BELOW POWER LINE	0	0	0.00	1	1		0	0	0	0.00	80	74	26.67

TABLE 7. Continued.

Site	Total adult toads	Max adult toads	Mean adult toads	Total toad metamorphs	Max toad metamorphs	Mean toad metamorphs	Total toad tadpoles	Total adult treefrogs	Max adult treefrogs	Mean adult treefrogs	Total treefrog metamorphs	Max treefrog metamorphs	Mean treefrog metamorphs
HONDA LAGOON- COAST RD	0	0	0.00	2	2	0.67	400	10	9		12	11	1.71
HONDA E BASE BDY	1	1		0	0	0.00	0	0	0	0.00	2	2	
HONDA CYN RD 1-3 XING	0	0	0.00	0	0	0.00	0	0	0	0.00	9	9	
JALAMA LAGOON-SPRR	0	0	0.00	73	45	11.83	1045	30	30		18	10	3.00
JOLLORU	1	1		0	0	0.00	0	3	2		44	43	
NEAR PT SAL	0	0	0.00	0	0	0.00	0	4	4		119	113	
OCEAN AVE DITCH	0	0	0.00	0	0	0.00	0	0	0	0.00	1	1	
SHUMAN LAGOON	0	0	0.00	0	0	0.00	0	11	10		39	22	8.50
YNEZ AT 13TH ST.	0	0	0.00	0	0	0.00	40	3	2		0	0	0.00
YNEZ ABOVE LAGOON	0	0	0.00	6	4	2.00	2	2	2	1.00	0	0	0.00
YNEZ WATER TRMT PLT	0	0	0.00	0	0	0.00	0	0	0	0.00	0	0	0.00
YNEZ AT 35TH	0	0	0.00	0	0	0.00		1	1		0	0	0.00

TABLE 8. Relative abundance of sensitive species of amphibians and reptiles, and bullfrogs (*Rana catesbeiana*), by habitat type at Vandenberg Air Force Base, California, from field surveys in 1995. Values for red-legged (*Rana aurora*) tadpoles and trapped western pond turtles (*Clemmys marmorata*) were calculated from the maximum total caught within a 24-hr period divided by the product of number of traps and minutes set. Spadefoot toad (*Spea hammondi*) tadpole values were calculated by number caught divided by number of net-sampling minutes. All others were calculated from maximum number observed during one visual survey, divided by the product of the survey minutes and number of observers. Garter snakes are the two-striped garter snake (*Thamnophis hammondi*). Sites are described in Table 1, and maximum values are given in Tables 4 through 6.

Site		Red-legged adults	Red-legged metamorphs	Red-legged tadpoles	Bullfrog adults	Spadefoot adults	Spadefoot tadpoles	Garter snakes	Turtles visual	Turtles trapped
<u>Vernal pools</u>										
Small										
	51						0.09			
Large										
	18					0.05	0.30			
	34					0.03	0.03			
<u>Ponds</u>										
Ephemeral										
	17	0.700								
	36	0.022			0.082					
	48				0.214					
	66				0.011					
	67				0.052					
	83		0.0167		0.017				0.017	
BEAR VALLEY										
Dune swale ponds										
	26	0.200		0.0008						
	27	0.250	0.0004	0.0022						
	47	0.133								
	71	0.145								
	72	0.009								
	75	0.013		0.0004						
	76	0.044								
	77	0.055								
	78	0.188								

TABLE 8. Continued.

Site	Red-legged adults	Red-legged metamorphs	Red-legged tadpoles	Bullfrog adults	Spadefoot adults	Spadefoot tadpoles	Garter snakes	Turtles visual	Turtles trapped
<u>Ponds (Cont.)</u>									
Small permanent									
29	0.067								
37									0.0001
58									0.0009
61	0.043								0.0008
63		0.3000	0.0003						
73	0.090		0.0004						
81	0.042								
85		0.0667	0.0016						
OCEAN AVE DITCH	0.033								
Large permanent, sparse vegetation									
60	0.050	0.6500	0.0079						0.0002
87	0.050	0.7500							
Large permanent, dense vegetation									
30	0.100		0.0001	0.050					
38	0.050	0.0222							0.0001
39	0.033	0.0750	0.0050						0.0002
45				0.036					0.0007
46									0.0069
<u>Streams</u>									
Lagoons									
ANTONIO LAGOON	0.133		0.0003						
HONDA LAGOON-COAST RD	0.042	0.0667	0.0001				0.025		
JALAMA LAGOON-SPRR	0.059	0.0033	0.0160				0.003		0.0042
SHUMAN LAGOON	0.043		0.0014						
YNEZ ABOVE LAGOON	0.035			0.017					

TABLE 8. Continued.

Site	Red-legged adults	Red-legged metamorphs	Red-legged tadpoles	Bullfrog adults	Spadefoot adults	Spadefoot tadpoles	Garter snakes	Turtles visual	Turtles trapped
<u>Streams</u>									
Deep									
ANTONIO AT SPRR	0.120								
CASMALIA/SHUMAN	0.011								
Shallow									
HONDA CYN RD 1-3 XING	0.009	0.0667					0.017		
HONDA BELOW POWER LINE							0.018		0.0017
HONDA TRANQ. MTN RD.	0.007						0.006	0.007	
NEAR PT SAL	0.007								
ANTONIO RD. W				0.009			0.009	0.028	
ANTONIO AT RECYC CTR				0.025					
ANTONIO AT STATE WATER				0.020					
ANTONIO AT HWY. 1	0.090			0.030			0.008	0.008	
Large, sparse vegetation									
YNEZ AT 13TH ST.				0.063					
YNEZ WATER TRMT PLT	0.005			0.037					
At bridge									
ANTONIO AT EL RANCHO	0.417								
ANTONIO AT L-C RD.	0.294			0.118					0.0003
ANTONIO MARSH S TRIB	0.167								

Appendix A. Field data sheet keys for amphibian and reptile sighting records and microhabitat use.

KEY TO SIGHTING RECORDS AND MICROHABITAT USE
OF AMPHIBIANS AND REPTILES
VERNAL POOLS OF CENTRAL CALIFORNIA

DATE: DayMonthYear.

OBSERVERS: first initials and last name. First observer listed is data recorder.

LOCALITY: area name, pool number on map.

HABITAT: "pool" = vernal pool, "wetland" = for wetland.

SEARCH: "day" or "night" + target of search, such as "eggs", "toads", "frogs", "systematic survey"

START/END TIME: 24-hour clock.

AIR TEMPERATURE: If applicable, measure in shade to nearest °F.

WATER TEMPERATURE: measure 3 cm below surface and at deepest point to nearest °F. If applicable, in shade.

CLOUD COVER: estimate to nearest 10%. Include fog.

WIND: C = calm G = gale
B = breeze approx. 10 mph U = undetermined
W = wind 10-20 mph

TIME: 24-hour clock.

SPECIES: S = *Spea hammondi* T = *Ambystoma californiense*
O = *Bufo boreas*

SIZE: S = small, if <30mm
L = large
E = eggs M = metamorph
T = tadpole U = undetermined

POSITION: describe position of focal animal in relation to edge of water.

Adults, Juveniles and Metamorphs

L = land & distance from water in m

W = water & distance from shore in m

E = half in and half out of water, on shallow edge

Larvae

S = shallow edge of pool

D = deep area of pool, on bottom

M = mid-water, at surface

Eggs

distance from shore in m/distance from water surface in cm

ADJACENT VEGETATION: describe two dominant types of vegetation immediately surrounding or under focal animal and percent occupied by those types within 0.5 m from focal animal.

A = algae, submergent vegetation

F = floating vegetation

J = rushes, sedges

C = cattails

T = tules

G = grasses

H = herbs

B = shrubby annuals (*Brassica* & *Rubus*)

U = undetermined

W = willow or baccharis

P = chaparral

I = ice plant

M = pampass grass

Y = Eucalyptus

R = roots

D = floating debris

O = open mineral substrate

S = open soil substrate

BANK VEGETATION: use above codes to describe three dominant vegetation types along a 10 meter transect perpendicular to focal animal and percent occupied by those types.

SUBSTRATE: indicate two dominant types near focal animal and percent of those types.

D = bedrock	S = sand 1-5 mm
B = boulders > 60 cm	F = fine sediments < 1mm
R = rock 30-60 cm	L = leaves or plants
C = cobble 7-30 cm	U = undetermined
G = gravel 5-70 mm	

FLOW: (ignore)

POND WIDTH: measure or estimate to nearest 0.5 meter.

BED WIDTH: (ignore)

LENGTH OF POND: measure or estimate to nearest 0.5 meter.

DEPTH: measure or estimate to nearest 0.1 meter at deepest location within 0.5 meter of focal animal.

CANOPY COVER: measure percent with densiometer.

NOTES: indicate number to be cross-referenced at bottom of data sheet. Also indicate sightings of other amphibians and reptiles seen. Designate life stage and number.

[Susan V. Christopher, Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara, 23 February 1995. Adapted from National Biological Service, Piedras Blancas Research Station, San Simeon, CA, 8 May 1992]

**KEY TO SIGHTING RECORDS AND MICROHABITAT USE
OF AMPHIBIANS AND REPTILES
STREAMS AND PONDS OF CENTRAL CALIFORNIA**

DATE: DayMonthYear.

OBSERVERS: first initials and last name. First observer listed is data recorder.

LOCALITY: stream name with specific reach indicated or pond number.

HABITAT: "stream" or "pond", & "perennial/permanent" or "intermittent/temporary".

SEARCH: "day" or "night" + target of search, such as "eggs", "toads", "frogs", "systematic survey".

START/END TIME: 24-hour clock.

AIR TEMPERATURE: measure in shade to nearest °F.

WATER TEMPERATURE: measure 3 cm below surface and at deepest point to nearest °F. If applicable, measure in shade.

CLOUD COVER: estimate to nearest 10%. Include fog.

WIND: C = calm G = gale
B = breeze approx. 10 mph U = undetermined
W = wind 10-20 mph

RAIN: indicate rain, showers, drizzle, or foggy mist and length of time since onset of precipitation.

TIME: 24-hour clock.

SPECIES: A = *Rana aurora* C = *Rana catesbeiana*
H = *Thamnophis hammondi* M = *Clemmys marmorata*
O = *Bufo boreas*

SIZE: S = small, if A < 60mm C < 75mm H < 300mm M < 100mm S, T & O < 30mm
L = large
E = eggs M = metamorph
T = tadpole U = undetermined

POSITION: describe position of focal animal in relation to edge of water.

Adults, Juveniles and Metamorphs

L = land & distance from water in m

W = water & distance from shore in m

E = half in and half out of water, on shallow edge

Larvae

S = shallow edge

D = deep area, on bottom

M = mid-water, at surface

Eggs

distance from shore in m / distance from water surface in cm

ADJACENT VEGETATION: describe two dominant types of vegetation immediately surrounding or under focal animal and percent occupied by those types within 0.5 m from focal animal.

A = algae, submergent vegetation

F = floating vegetation

J = rushes, sedges

C = cattails

T = tules

G = grasses

H = herbs

B = shrubby annuals (*Brassica* & *Rubus*)

Q = oak

U = undetermined

W = willow or baccharis

P = chaparral

I = ice plant

M = pampass grass

Y = Eucalyptus

R = roots

D = floating debris

O = open mineral substrate

S = open soil substrate

BANK VEGETATION: use above codes to describe three dominant vegetation types along a 10 meter transect perpendicular to focal animal and percent occupied by those types.

SUBSTRATE: indicate two dominant types near focal animal and percent of those types.

D = bedrock	S = sand 1-5 mm
B = boulders > 60 cm	F = fine sediments < 1mm
R = rock 30-60 cm	L = leaves or plants
C = cobble 7-30 cm	U = undetermined
G = gravel 5-70 mm	

FLOW (STREAMS):

P = pool
G = glide

R = riffle
S = side pool or channel

STREAM/POND WIDTH: measure or estimate from wetted shore to shore to nearest 0.5 meter.

BED WIDTH (STREAMS): measure or estimate active stream channel to nearest 0.5 meter.

LENGTH OF POOL: measure or estimate stream pool or pond length to nearest 0.5 meter.

DEPTH: measure or estimate to nearest 0.1 meter at location of focal animal.

CANOPY COVER: measure percent with densiometer.

NOTES: indicate number to be cross-referenced at bottom of data sheet. Also indicate sightings of other amphibians and reptiles seen by life stage and number.

[Susan V. Christopher, Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara, 10 April 1995. Adapted from National Biological Service, Piedras Blancas Research Station, San Simeon, CA, 8 May 1992]

Appendix B. Field data sheet for amphibian and reptile sighting records and microhabitat use.

TIME: START END CLOUDS: START END

WIND:

RAIN:

[illegible]

NO. PSRE:
CALLING

EGGS

TADPOLES

METAMORPHS

ADULTS

NOTES: